

Diminishing benefits of urban living for children and adolescents' growth and development

<https://doi.org/10.1038/s41586-023-05772-8>


NCD Risk Factor Collaboration (NCD-RisC)*

Received: 27 May 2022

Accepted: 30 January 2023

Published online: 29 March 2023

Open access

 Check for updates

Optimal growth and development in childhood and adolescence is crucial for lifelong health and well-being^{1–6}. Here we used data from 2,325 population-based studies, with measurements of height and weight from 71 million participants, to report the height and body-mass index (BMI) of children and adolescents aged 5–19 years on the basis of rural and urban place of residence in 200 countries and territories from 1990 to 2020. In 1990, children and adolescents residing in cities were taller than their rural counterparts in all but a few high-income countries. By 2020, the urban height advantage became smaller in most countries, and in many high-income western countries it reversed into a small urban-based disadvantage. The exception was for boys in most countries in sub-Saharan Africa and in some countries in Oceania, south Asia and the region of central Asia, Middle East and north Africa. In these countries, successive cohorts of boys from rural places either did not gain height or possibly became shorter, and hence fell further behind their urban peers. The difference between the age-standardized mean BMI of children in urban and rural areas was $<1.1 \text{ kg m}^{-2}$ in the vast majority of countries. Within this small range, BMI increased slightly more in cities than in rural areas, except in south Asia, sub-Saharan Africa and some countries in central and eastern Europe. Our results show that in much of the world, the growth and developmental advantages of living in cities have diminished in the twenty-first century, whereas in much of sub-Saharan Africa they have amplified.

The growth and development of school-aged children and adolescents (ages 5–19 years) are influenced by their nutrition and environment at home, in the community and at school. Healthy growth and development at these ages help consolidate gains and mitigate inadequacies from early childhood and vice versa¹, with lifelong implications for health and well-being^{2–6}. Until recently, the growth and development of older children and adolescents received substantially less attention than in early childhood and adulthood⁷. Increasing attention on the importance of health and nutrition during school years has been accompanied by a presumption that differences in nutrition and the environment lead to distinct, and generally less healthy, patterns of growth and development at these ages in cities compared to rural areas^{8–17}. This presumption is despite some empirical studies showing that food quality and nutrition are better in cities^{18,19}.

Data on growth and developmental outcomes during school ages are needed, alongside data on the efficacy of specific interventions and policies, to select and prioritize policies and programmes that promote health and health equity, both for the increasing urban population and for children who continue to grow up in rural areas. Consistent and comparable global data also help benchmark across countries and territories and draw lessons on good practice. Yet, globally, there are fewer data on growth trajectories in rural and urban areas in these formative ages than

for children under 5 years of age²⁰ or for adults²¹. The available studies have been in one country, at one point in time and/or in one sex and narrow age groups. The few studies that covered more than one country^{22–24} mostly focused on older girls and used at most a few dozen data sources and hence could not systematically measure long-term trends. Consequently, many policies and programmes that aim to enhance healthy growth and development in school ages focus narrowly and generically on specific features of nutrition or the environment in either cities or rural areas^{10,13,25–28}. Little attention has been paid to the similarities and differences between relevant outcomes in these settings or to the heterogeneity of the urban–rural differences across countries.

Here we report on the mean height and BMI of school-aged children and adolescents residing in rural and urban areas of 200 countries and territories (referred to as countries hereafter) from 1990 to 2020. Height and BMI are anthropometric measures of growth and development that are influenced by the quality of nutrition and healthiness of the living environment and are highly predictive of health and well-being throughout life in observational and Mendelian randomization studies^{2–6}. These studies have shown that having low height and excessively low BMI increases the risk of morbidity and mortality, and low height impairs cognitive development and reduces educational performance and work productivity in later life^{2–4}. A high BMI in these

*A list of authors and their affiliations appears online.

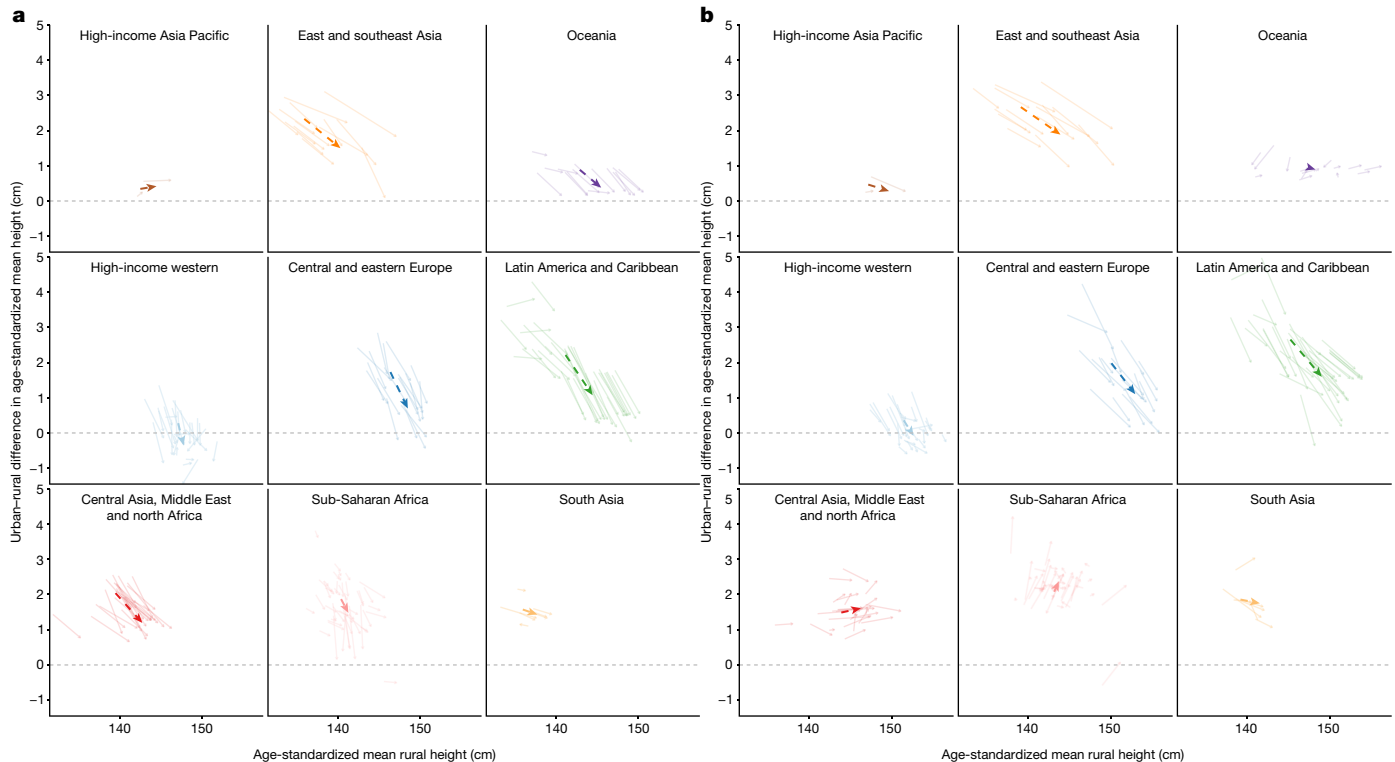


Fig. 1 | Change in the urban-rural height difference from 1990 to 2020.

a, b, Change in the urban-rural difference in age-standardized mean height in relation to the change in age-standardized mean rural height in girls (**a**) and boys (**b**). Each solid arrow in lighter shade shows one country beginning in 1990 and ending in 2020. The dashed arrows in darker shade show the regional averages, calculated as the unweighted arithmetic mean of the values for all countries in each region along the horizontal and vertical axes. For the urban-rural difference, a positive number shows a higher urban mean height and a

negative number shows higher rural mean height. See Extended Data Fig. 2 for urban-rural differences in age-standardized mean height and their change over time shown as maps, together with uncertainties in the estimates. See Supplementary Fig. 4a for results at ages 5, 10, 15 and 19 years. We did not estimate the difference between rural and urban height for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau).

ages increases the lifelong risk of overweight and obesity and several non-communicable diseases, and might contribute to poor educational outcomes^{5,6}.

We used 2,325 population-based studies that measured height and weight in 71 million participants in 194 countries (Extended Data Fig. 1 and Supplementary Table 2). We used these data in a Bayesian hierarchical meta-regression model to estimate mean height and BMI of children and adolescents aged 5–19 years by rural and urban place of residence, year and age for 200 countries. Details of data sources and statistical methods are provided in the Methods. Our results represent the height and BMI for children and adolescents of the same age over time (that is, successive cohorts) in rural and urban areas of each country, and the difference between the two. For presentation, we summarize the 15 age-specific estimates, for single years of age from 5 to 19, through age standardization, which puts each country-year's child and adolescent population on the same age distribution and enables comparisons to be made over time and across countries. We also show results, graphically and numerically, for index ages of 5, 10, 15 and 19 years in the Supplementary Information.

In 1990, school-aged boys and girls who lived in cities had a height advantage (that is, were taller) compared with their rural counterparts. The exception was in high-income countries, where the urban height advantage was either negligible (<1.2 cm for age-standardized mean height; posterior probability (PP) for children living in urban areas being taller ranging from 0.51 to >0.99) or there was a small rural advantage (for example, Belgium, the Netherlands and the United Kingdom) (PP for children in rural areas being taller ranging from 0.53 to >0.95 where there was a rural height advantage) (Fig. 1 and Extended Data Fig. 2). The

largest height differences between children and adolescents in cities and rural areas in 1990 occurred in some countries in Latin America (for example, Mexico, Guatemala, Panama and Peru), east and southeast Asia (China, Indonesia and Vietnam), central and eastern Europe (Bulgaria, Hungary and Romania) and sub-Saharan Africa (Democratic Republic of Congo (DR Congo) and Rwanda). The urban height advantage in boys and girls in the named countries ranged from 2.4 to 5.0 cm, and the PP of children living in urban areas being taller than children living in rural areas was >0.99 (see Supplementary Table 3 for country-specific numerical values of height in children living in rural versus urban areas, their difference and the corresponding credible intervals (CrIs)).

The urban-rural height gap in the late twentieth century among low-income and middle-income countries was determined by how much children and adolescents in cities and rural areas had approached as opposed to fallen behind their peers in high-income countries, where there was little difference between urban and rural height. In countries such as Bulgaria, Hungary and Romania, the height of children and adolescents living in urban areas approached that of high-income countries, whereas children and adolescents in rural areas lagged behind, leading to a relatively large gap. In much of sub-Saharan Africa and south Asia, the height of children and adolescents lagged behind their peers in high-income countries regardless of where they lived, such that the urban-rural gap was relatively small. In a third group of low-income or middle-income countries that included Indonesia, Vietnam, Panama, Peru, DR Congo and Rwanda, children living in urban areas remained shorter than in high-income countries, but children from rural areas lagged even further behind, such that the urban-rural gap became large.

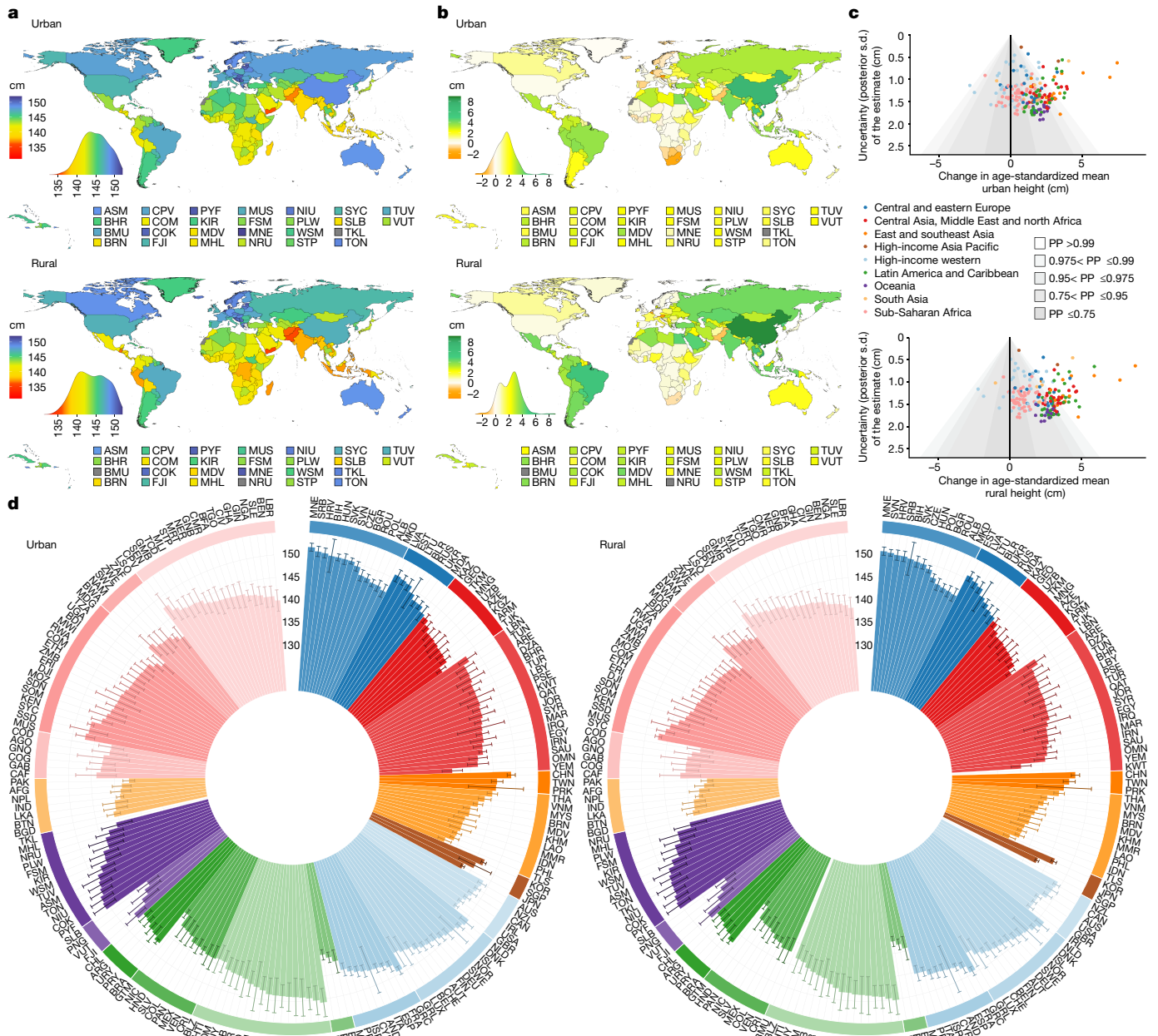


Fig. 2 | See next page for caption.

By 2020, the urban height advantage in school ages became smaller in much of the world. In many high-income western countries and some central European countries, it disappeared or reversed into a small (typically <1 cm) urban disadvantage (Fig. 1 and Extended Data Figs. 2 and 8). Countries with substantial convergence over these three decades were in central and eastern Europe (for example, Croatia), Latin America and the Caribbean (for example, Argentina, Brazil, Chile and Paraguay), east and southeast Asia (for example, Taiwan) and for girls in central Asia (for example, Kazakhstan and Uzbekistan). The urban height advantage in the named countries declined by around 1–2.5 cm from 1990 to 2020 (the PP of urban–rural height difference having declined ≥ 0.90 for the named countries). In many other middle-income countries (for example, China, Romania and Vietnam), the urban–rural height gaps declined, but children and adolescents living in cities remained taller than their rural counterparts (by 1.7–2.5 cm in the named countries for boys and girls; the PP of children in cities being taller than children in rural areas in 2020 >0.99). The exception to this

convergence was for boys in most countries in sub-Saharan Africa and some countries in Oceania, south Asia and the region of central Asia, Middle East and north Africa, where the urban height advantage slightly increased over these three decades. The largest increase in the urban height advantage for boys occurred in countries in east Africa such as Ethiopia (0.9 cm larger height gap in 2020 than 1990; 95% CrI –0.9 to 2.9, and PP of an increase of 0.86), Rwanda (1.0 cm larger gap, 95% CrI –0.7 to 3.0, and PP 0.88) and Uganda (1.1 cm larger gap, 95% CrI of –0.6 to 3.1, and PP 0.89). For girls, the urban–rural gap remained largely unchanged in many countries in sub-Saharan Africa and south Asia.

In middle-income countries and emerging economies (newly high-income and industrialized countries) where the height of children and adolescents residing in rural areas converged to those in cities, successive cohorts of children and adolescents living in rural areas outpaced their urban counterparts in becoming taller and attained heights that urban children in the same countries had done decades earlier: growing to heights closer to those seen in high-income countries

Fig. 2 | Urban and rural height in 2020 and the change from 1990 to 2020

for girls. a, Age-standardized mean height in 2020 by urban and rural place of residence for girls. The density plots show the distribution of estimates across countries. **b**, Age-standardized change in mean height from 1990 to 2020 by urban and rural place of residence for girls. The density plots show the distribution of estimates across countries. **c**, Change in mean height from 1990 to 2020 in relation to the uncertainty of the change measured by posterior standard deviation. Each point in the scatter plots shows one country. Shaded areas approximately show the PP of an estimated change being a true increase or decrease. The PP of a decrease is one minus that of an increase. If an increase in mean height is statistically indistinguishable from a decrease, the PP of an increase and a decrease is 0.50. PPs closer to 0.50 indicate more uncertainty, whereas those towards 1 indicate more certainty of change. **d**, Age-standardized mean height in 2020 for all countries. The height of each column is the posterior mean estimate shown together with its 95% CrI. Countries are ordered by region and super-region. See Extended Data Fig. 4 for a map of PP of the estimated change. See Supplementary Fig. 5 for results at ages 5, 10, 15 and 19 years. See Supplementary Table 3 for numerical results, including CrIs, as age-standardized and at ages 5, 10, 15 and 19 years. We did not estimate mean rural height in countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore), mean urban height in countries classified as entirely rural (Tokelau) or their change over time in these countries, as indicated in grey. Countries are labelled using their International Organization for Standardization (ISO) 3166-1 alpha-3 codes. Afghanistan, AFG; Albania, ALB; Algeria, DZA; American Samoa, ASM; Andorra, AND; Angola, AGO; Antigua and Barbuda, ATG; Argentina, ARG; Armenia, ARM; Australia, AUS; Austria, AUT; Azerbaijan, AZE; Bahamas, BHS; Bahrain, BHR; Bangladesh, BGD; Barbados, BRB; Belarus, BLR; Belgium, BEL; Belize, BLZ; Benin, BEN; Bermuda, BMU; Bhutan, BTN; Bolivia, BOL; Bosnia and Herzegovina, BIH; Botswana, BWA; Brazil, BRA; Brunei Darussalam, BRN; Bulgaria, BGR; Burkina Faso, BFA; Burundi, BDI; Cabo Verde, CPV; Cambodia, KHM; Cameroon, CMR; Canada, CAN; Central African Republic, CAF; Chad, TCD; Chile, CHL; China, CHN; Colombia, COL; Comoros, COM; Congo, COG; Cook Islands, COK; Costa Rica, CRI; Cote d'Ivoire, CIV;

Croatia, HRV; Cuba, CUB; Cyprus, CYP; Czechia, CZE; Denmark, DNK; Djibouti, DJI; Dominica, DMA; Dominican Republic, DOM; DR Congo, COD; Ecuador, ECU; Egypt, EGY; El Salvador, SLV; Equatorial Guinea, GNO; Eritrea, ERI; Estonia, EST; Eswatini, SWZ; Ethiopia, ETH; Fiji, FJI; Finland, FIN; France, FRA; French Polynesia, PYF; Gabon, GAB; Gambia, GMB; Georgia, GEO; Germany, DEU; Ghana, GHA; Greece, GRC; Greenland, GRL; Grenada, GRD; Guatemala, GTM; Guinea Bissau, GNB; Guinea, GIN; Guyana, GUY; Haiti, HTI; Honduras, HND; Hungary, HUN; Iceland, ISL; India, IND; Indonesia, IDN; Iran, IRN; Iraq, IRQ; Ireland, IRL; Israel, ISR; Italy, ITA; Jamaica, JAM; Japan, JPN; Jordan, JOR; Kazakhstan, KAZ; Kenya, KEN; Kiribati, KIR; Kuwait, KWT; Kyrgyzstan, KGZ; Lao PDR, LAO; Latvia, LVA; Lebanon, LBN; Lesotho, LSO; Liberia, LBR; Libya, LBY; Lithuania, LTU; Luxembourg, LUX; Madagascar, MDG; Malawi, MWI; Malaysia, MYS; Maldives, MDV; Mali, MLI; Malta, MLT; Marshall Islands, MHL; Mauritania, MRT; Mauritius, MUS; Mexico, MEX; Micronesia (Federated States of), FSM; Moldova, MDA; Mongolia, MNG; Montenegro, MNE; Morocco, MAR; Mozambique, MOZ; Myanmar, MMR; Namibia, NAM; Nauru, NRU; Nepal, NPL; Netherlands, NLD; New Zealand, NZL; Nicaragua, NIC; Niger, NER; Nigeria, NGA; Niue, NIU; North Korea, PRK; North Macedonia, MKD; Norway, NOR; Occupied Palestinian Territory, PSE; Oman, OMN; Pakistan, PAK; Palau, PLW; Panama, PAN; Papua New Guinea, PNG; Paraguay, PRY; Peru, PER; Philippines, PHL; Poland, POL; Portugal, PRT; Puerto Rico, PRI; Qatar, QAT; Romania, ROU; Russian Federation, RUS; Rwanda, RWA; Saint Kitts and Nevis, KNA; Saint Lucia, LCA; Samoa, WSM; Sao Tome and Principe, STP; Saudi Arabia, SAU; Senegal, SEN; Serbia, SRB; Seychelles, SYC; Sierra Leone, SLE; Singapore, SGP; Slovakia, SVK; Slovenia, SVN; Solomon Islands, SLB; Somalia, SOM; South Africa, ZAF; South Korea, KOR; South Sudan, SSD; Spain, ESP; Sri Lanka, LKA; Saint Vincent and the Grenadines, VCT; Sudan, SDN; Suriname, SUR; Sweden, SWE; Switzerland, CHE; Syrian Arab Republic, SYR; Taiwan, TWN; Tajikistan, TJK; Tanzania, TZA; Thailand, THA; Timor-Leste, TLS; Togo, TGO; Tokelau, TKL; Tonga, TON; Trinidad and Tobago, TTO; Tunisia, TUN; Turkey, TUR; Turkmenistan, TKM; Tuvalu, TUV; Uganda, UGA; Ukraine, UKR; United Arab Emirates, ARE; United Kingdom, GBR; United States of America, USA; Uruguay, URY; Uzbekistan, UZB; Vanuatu, VUT; Venezuela, VEN; Vietnam, VNM; Yemen, YEM; Zambia, ZMB.

(Figs. 2 and 3). Successive cohorts of children and adolescents residing in rural areas in sub-Saharan Africa did not experience the accelerated height gain seen in cohorts in rural areas of middle-income countries. Notably, in the case of boys living in sub-Saharan Africa, there was no gain, or possibly a decrease, in height, which in turn led to a persistence or even widening of the urban–rural gap. As a result of these global trends, by 2020, the largest urban–rural gaps in height were seen in Andean and central Latin America (for example, Bolivia, Panama and Peru, by up to 4.7 cm (95% CrI 4.0–5.5 cm) for boys and 3.8 cm (95% CrI 3.3–4.3 cm) for girls) and, especially for boys, in sub-Saharan Africa (for example, DR Congo, Ethiopia, Mozambique and Rwanda, by up to 4.2 cm (95% CrI 2.7–5.7 cm)).

The urban–rural BMI difference was relatively small throughout these three decades, <1.4 kg m⁻² in all countries and years and <1.1 kg m⁻² in all but nine countries, for age-standardized mean BMI (Fig. 4 and Extended Data Figs. 3 and 9). In 1990, the urban–rural BMI gap was largest in sub-Saharan Africa (for example, Ethiopia, Kenya, Malawi, South Africa and Zimbabwe) and south Asia (for example, Bangladesh and India), followed by parts of Latin America (for example, Mexico and Peru). The urban–rural BMI gap in the two sexes in the named countries ranged from 0.4 to 1.2 kg m⁻², and the PP of children and adolescents living in urban areas having a higher BMI than those in rural areas was ≥0.89. At that time, girls and/or boys in rural areas of some of these countries had mean BMI levels that were close to, and in some ages below, the thresholds of being underweight (>1 s.d. below the median of the World Health Organization (WHO) reference population).

From 1990 to 2020, the BMI of successive cohorts of children and adolescents in both urban and rural areas increased in all but a few mostly high-income countries (for example, Denmark, Italy and Spain) (Figs. 5 and 6). There was heterogeneity in low-income and middle-income countries in how much the BMI increased in cities compared with rural areas. In the majority of countries in sub-Saharan Africa

and south Asia, the BMI of successive cohorts of children and adolescents increased more in rural areas than in cities, leading to a closing of the urban–rural difference. The urban–rural BMI gap declined by up to 0.65 kg m⁻² for both girls and boys, and the PP that the urban–rural BMI difference declined from 1990 to 2020 ranged from 0.52 to 0.95. In both sub-Saharan Africa and south Asia, these changes shifted the mean BMI of boys and girls in rural areas out of the range for being underweight. Moreover, in many countries in sub-Saharan Africa, this shift continued beyond the median of the WHO reference population and in some cases approached the threshold for being overweight (>1 s.d. above the median of the WHO reference population). The opposite, a larger increase in urban BMI, happened in most other low-income and middle-income countries, leading to a slightly larger urban BMI excess in 2020 than in 1990. High-income countries and those in central and eastern Europe experienced a mix of increasing and decreasing urban BMI excess, but remained within a small range (–0.3 to 0.6 kg m⁻² for almost all countries) over the entire period of analysis. At the regional level, the urban–rural BMI difference changed by <0.25 kg m⁻² in these regions.

The urban height advantage was larger in boys than girls in most countries (Supplementary Fig. 3). Urban excess BMI was larger in boys than girls in only about one-half of the countries. For the other half, mostly in high-income western countries and those in sub-Saharan Africa, urban excess BMI was larger in girls than boys. The urban height advantage was slightly larger at 5 years of age than at 19 years of age in most low-income and middle-income countries, especially for girls, but there was little difference across ages in high-income regions and in central and eastern Europe (Supplementary Fig. 4).

Since the introduction of modern sanitation in the nineteenth century, cities provided substantial nutritional and health advantages in high-income and subsequently low-income and middle-income countries¹⁹. Our results show that in the twenty-first century, during school

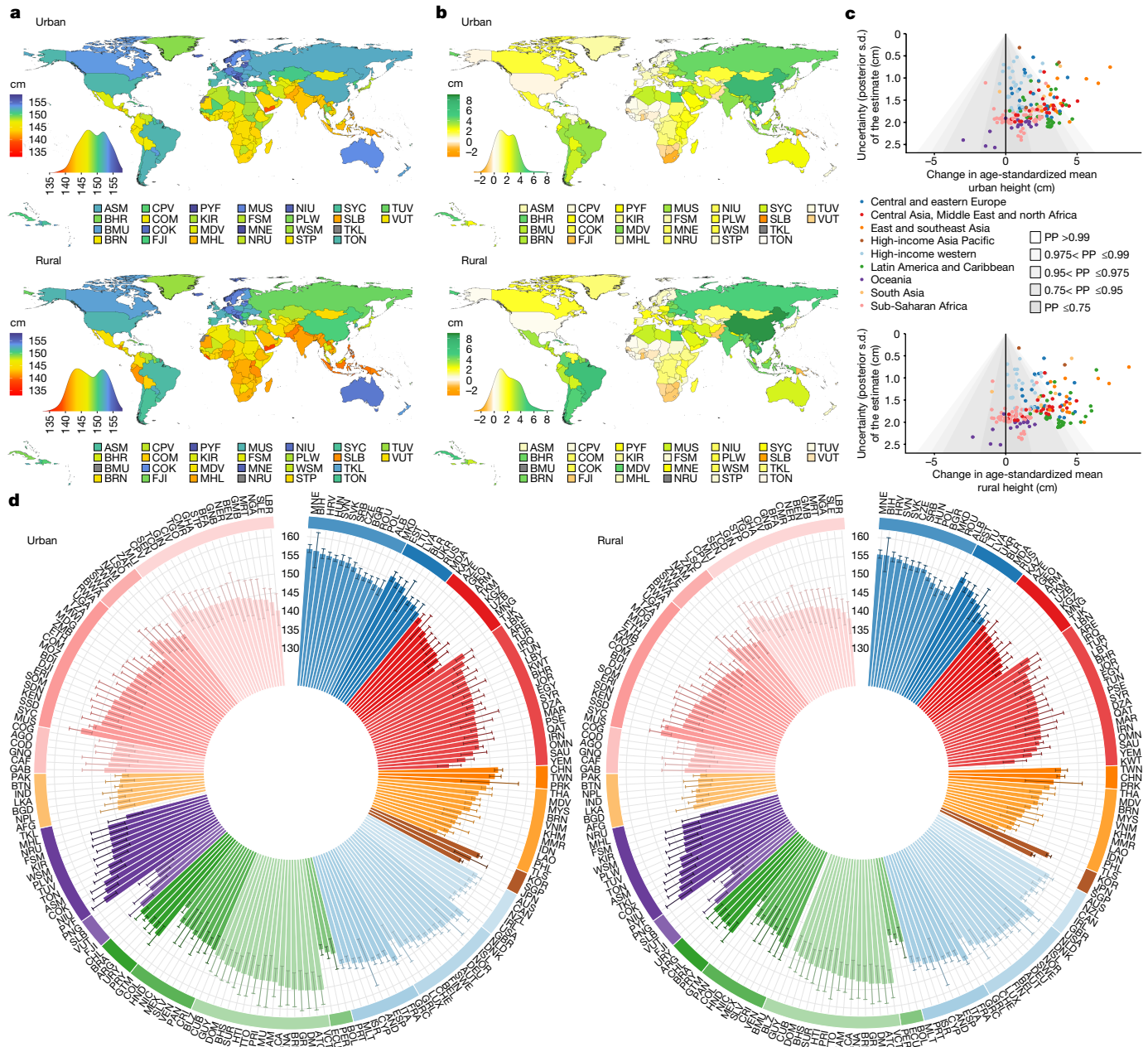


Fig. 3 | Urban and rural height in 2020 and change from 1990 to 2020 for boys. a–d. See the caption for Fig. 2 for descriptions of the contents of the figure and for definitions. We did not estimate mean rural height in countries

classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore), mean urban height in countries classified as entirely rural (Tokelau) or their change over time, as indicated in grey.

ages, these advantages have disappeared in high-income countries and diminished in middle-income countries and emerging economies in Asia, Latin America and the Caribbean, and parts of Middle East and north Africa. Specifically, in these settings, successive cohorts of school-aged children and adolescents living in cities were outpaced by those in rural areas in terms of height gain but gained slightly more weight by 2020, typically in the unhealthy range (Fig. 7). This contrasted with the poorest region in the world: sub-Saharan Africa. In this region, the urban height advantage persisted or even expanded, whereas rural mean BMI went beyond remedying underweight and surpassed the median of the WHO reference population in 2020, hence consolidating the urban advantage. South Asia had a mixed pattern of urban versus rural trends from 1990 to 2020, with children and adolescents in rural areas gaining both more height and more weight for their height than those in cities. Notably, our

results also show that differences in height and BMI between urban and rural populations within most countries are smaller than the differences across countries, even those in the same region.

We also found that the urban–rural BMI gap, although dynamic, changed much less than the BMI of either subgroup of the population and less than commonly assumed when discussing the role of cities in the obesity epidemic^{8,10,12,13,15,16}. Urban–rural BMI differences were especially small in high-income countries, which is consistent with evidence from a few countries that show diets and behaviours are affected more by household socioeconomic status than whether children and adolescents live in cities or rural areas^{29,30}. Urban BMI excess increased slightly more in middle-income countries in east and southeast Asia, Latin America and the Caribbean, and Middle East and north Africa, a trend that was the opposite of the convergence in BMI of

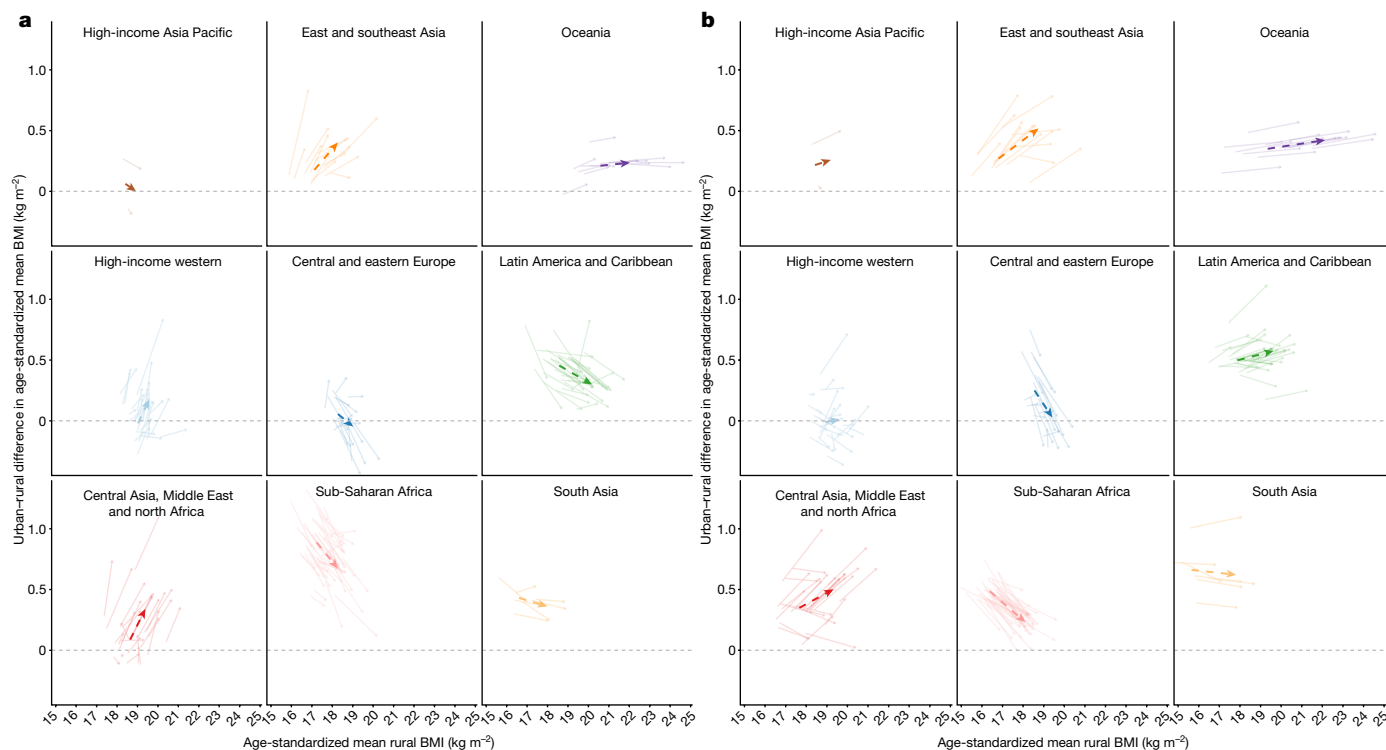


Fig. 4 | Change in the urban-rural BMI difference from 1990 to 2020.

a, b, Change in urban-rural difference in age-standardized mean BMI for girls (**a**) and boys (**b**) in relation to change in age-standardized mean rural BMI. See the caption for Fig. 1 for a description of the contents of this figure. See Extended Data Fig. 3 for urban-rural differences in age-standardized mean BMI and their

change over time shown as maps, together with uncertainties in the estimates. See Supplementary Fig. 4b for results at ages 5, 10, 15 and 19 years. We did not estimate the difference between rural and urban BMI for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau).

adults in these same regions²¹. Additional analyses of data collected by the NCD Risk Factor Collaboration (NCD-RisC) for young adults (20–29 and 30–39 years) showed that the shift from a small divergent trend to convergence of BMI between urban and rural areas happens in young adulthood (Extended Data Figs. 6 and 7), a period during which there is substantial, but variable, weight gain among population subgroups³¹. These shifts in trends from adolescence to young adulthood might be a result of changes in diet and energy expenditure that accompany changes in household structure, social and economic roles and the living environment^{32–34}.

Long-term follow-up studies have shown that children and adolescents do not achieve their height potential if they do not consume sufficient and diverse nutritious foods or if they are exposed to repeated or persistent infections, which result in loss of nutrients². Studies that use data on household socioeconomic and environmental factors have indicated that these physiological determinants of height are themselves affected by income, education, quality of the living environment and access to healthcare in rural as well as urban areas³⁵. This evidence indicates that the relatively small urban-rural height differentials in high-income countries may be because of a greater abundance of nutritious foods, including some fortified foods, better education and healthcare and greater ability to finance programmes that promote healthy growth in countries with greater per-capita income and better infrastructure. Variations across these countries in the urban-rural height gap within this small range may be due to the extent of socioeconomic inequalities and poverty, differences in the availability and cost of nutritious foods between cities and rural areas and whether there are specific programmes (for example, food assistance or school food programmes) that improve nutrition in disadvantaged groups^{30,36,37}. The more marked changes in height in urban versus rural areas took place in middle-income countries and emerging economies. Case studies in

some countries where the heights of children and adolescents living in rural and urban areas converged show that the convergence was partly due to using the growth in national income towards programmes and services that helped close gaps in nutrition, sanitation and healthcare between different areas and social groups^{38–40}. In countries in central and eastern Europe, transition to a market economy and increases in trade may have reduced the disparity in access to, and seasonality of, healthy foods between urban and rural areas⁴¹, and partly underlie the convergence of height seen in our results. By contrast, case studies in some countries have shown that where economic growth was accompanied by large inequalities in income, nutrition and/or services, the urban advantage persisted^{42–44}.

The notable exception in the global trends was sub-Saharan Africa, where a stagnation or reversal of height gain in rural areas led to the persistence or widening of urban-rural height differences, whereas the opposite happened for BMI (Fig. 7). Case studies of specific countries have indicated that unfavourable trends in nutrition in rural Africa, where the majority of the poorest people in the world live, started from macroeconomic shocks in the late twentieth century⁴⁵ and subsequent agriculture, trade and development policies that limited improvements in income and services, and emphasized agricultural exports over local food security and diversity⁴⁵. These macroeconomic factors in turn led to less diverse diets, with higher caloric intake rather than a shift to protein-rich and nutrient-rich foods (for example, animal products, seafood, fruits and vegetables)^{46–48}. Moreover, the slow expansion of infrastructure and services in rural areas restricted improvements in other determinants of healthy growth, such as clean water, sanitation and health care⁴⁹.

Several other factors may have had a secondary role in the observed trends in height and BMI and their difference in rural and urban areas. First, weight gain during childhood may reduce the age of puberty

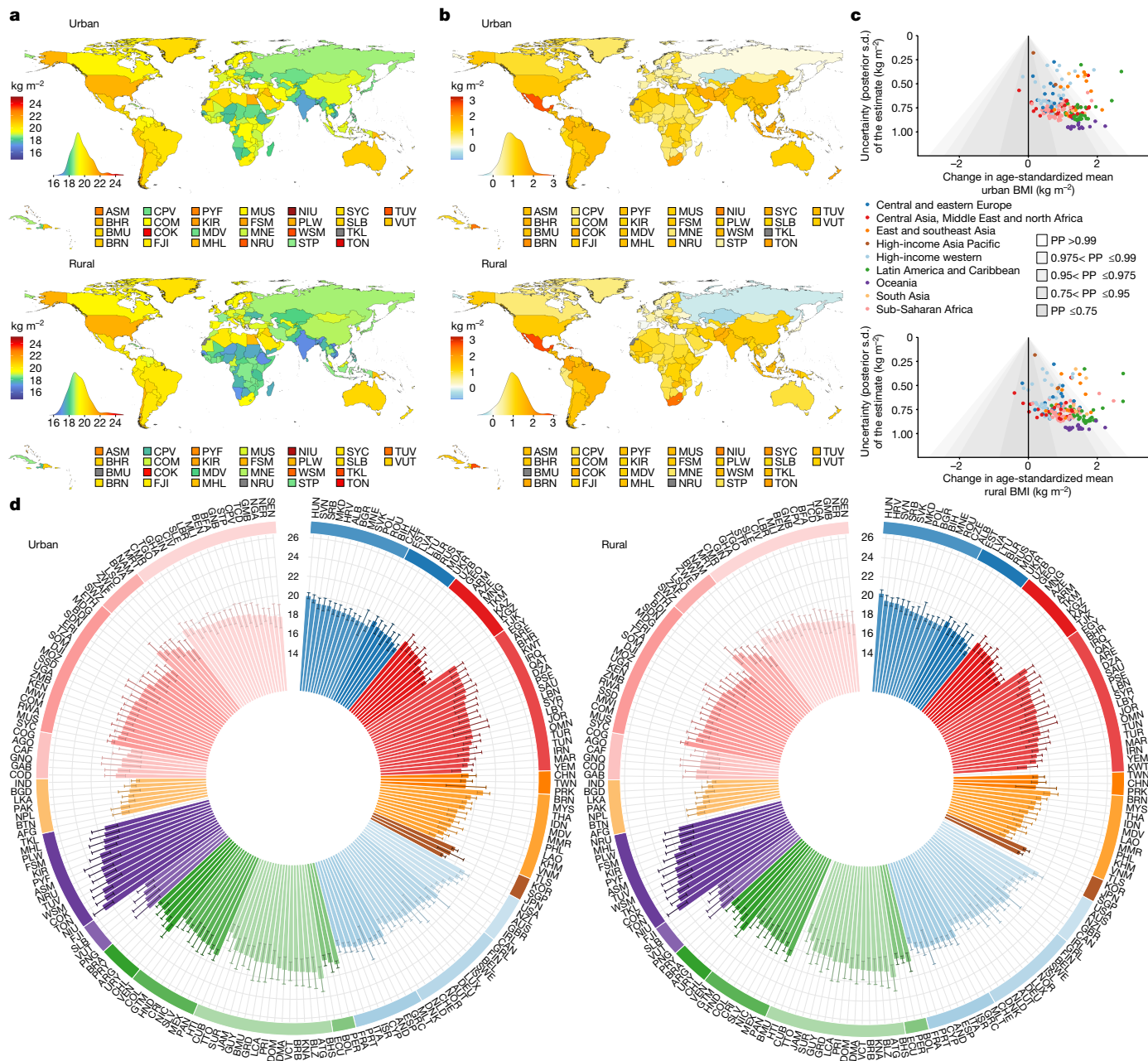


Fig. 5 | Urban and rural BMI in 2020 and change from 1990 to 2020 for girls. **a–d.** See the caption for Fig. 2 for descriptions of the contents of the figure and for definitions. See Extended Data Fig. 5 for a map of PP of the estimated change. See Supplementary Fig. 6 for results at ages 5, 10, 15 and 19 years. See Supplementary Table 4 for numerical results, including CIs, as age-standardized

and at ages 5, 10, 15 and 19 years. We did not estimate mean rural BMI in countries classified as entirely urban (Singapore, Bermuda and Nauru), mean urban BMI in areas classified as entirely countries (Tokelau) or their change over time, as indicated in grey.

onset, which in turn may limit height gain during adolescence^{50,51}. No comparable global data currently exist on age at menarche and timing of pubertal growth, even at the national level. Second, rural-to-urban migration and reclassification of previously rural areas to urban as they grow and industrialize may account for some of the observed population-level trends. However, migration tends to be less common in childhood and adolescence than in adulthood in most countries. Finally, improvements in survival among children aged under 5 years in rural areas, particularly low-birthweight children, may have influenced the height and weight of those who survive beyond 5 years of age. However, current data on changes in child survival in rural and urban areas in sub-Saharan Africa are limited and inconclusive in terms of whether mortality declined faster in rural or urban areas^{52,53}.

As attention in global health turns to children and adolescents, there is a need to consider and evaluate how growth and development in these formative ages may be affected both by social and economic policies that influence household income and poverty and by programmes that affect nutrition, health services, infrastructure and living environments in rural and urban areas. The need to identify, implement and evaluate policies and programmes that improve growth and development outcomes is particularly relevant as the increase in poverty and the cost of food, especially of nutrient-rich foods, as a result of the macroeconomic changes resulting from the COVID-19 pandemic and the war in Ukraine, may hinder further gains or even set back healthy growth and development in children and adolescents.

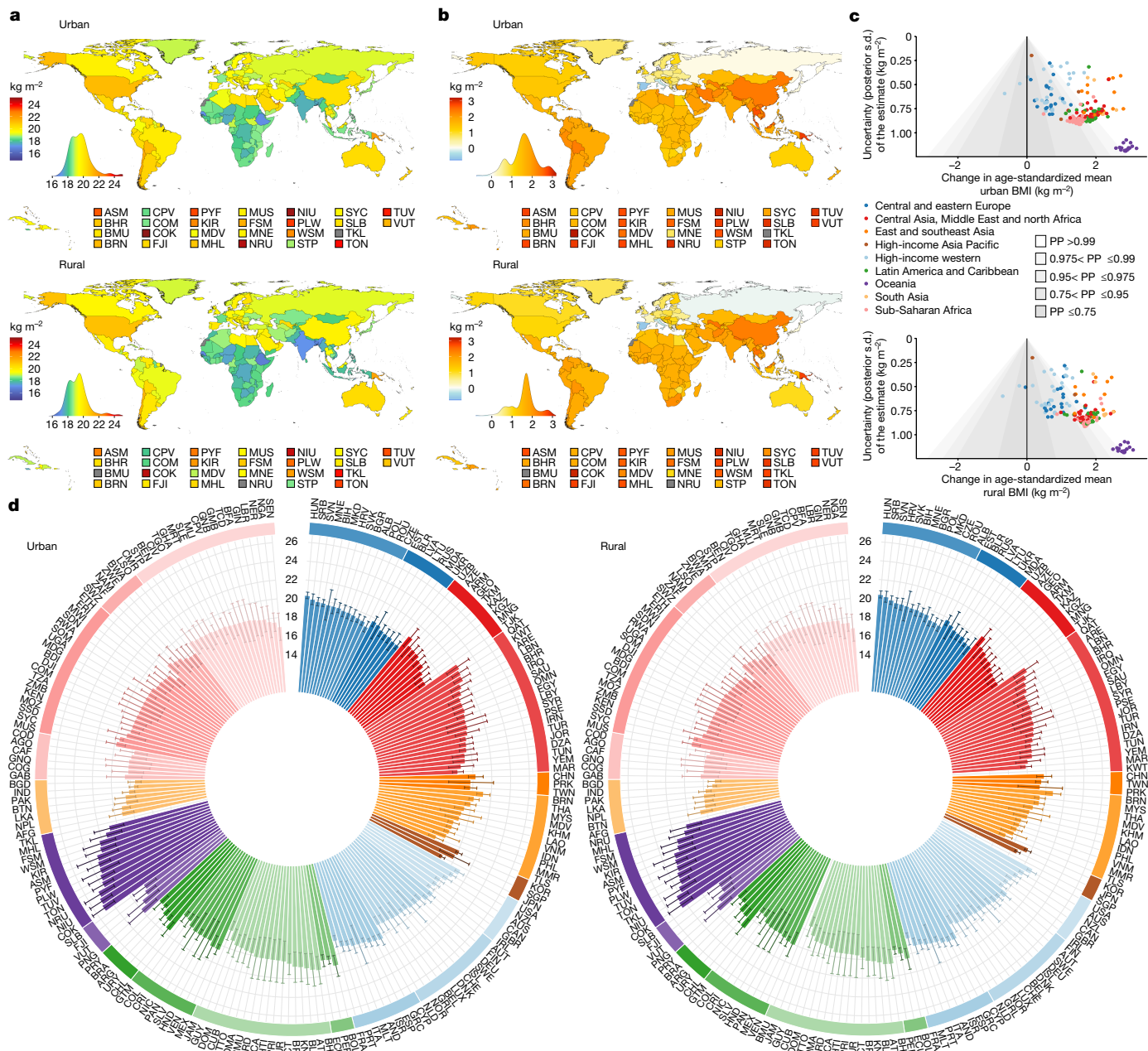


Fig. 6 | Urban and rural BMI in 2020 and change from 1990 to 2020 for boys. a–d, See the caption for Fig. 2 for descriptions of the contents of the figure and for definitions. We did not estimate mean rural BMI in countries classified as

entirely urban (Singapore, Bermuda and Nauru), mean urban BMI in countries classified as entirely rural (Tokelau) or their change over time, as indicated in grey.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at <https://doi.org/10.1038/s41586-023-05772-8>.

- Prentice, A. M. et al. Critical windows for nutritional interventions against stunting. *Am. J. Clin. Nutr.* **97**, 911–918 (2013).
- Tanner, J. M. Growth as a mirror of the condition of society: secular trends and class distinctions. *Acta Paediatr. Jpn.* **29**, 96–103 (1987).
- Strauss, J. & Thomas, D. Health, nutrition, and economic development. *J. Econ. Lit.* **36**, 766–817 (1998).
- Nüesch, E. et al. Adult height, coronary heart disease and stroke: a multi-locus Mendelian randomization meta-analysis. *Int. J. Epidemiol.* **45**, 1927–1937 (2016).

- Park, M. H., Falconer, C., Viner, R. M. & Kinra, S. The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. *Obes. Rev.* **13**, 985–1000 (2012).
- Caird, J. et al. Does being overweight impede academic attainment? A systematic review. *Health Educ. J.* **73**, 497–521 (2014).
- NCD Risk Factor Collaboration (NCD-RisC). Height and body-mass index trajectories of school-aged children and adolescents from 1985 to 2019 in 200 countries and territories: a pooled analysis of 2181 population-based studies with 65 million participants. *Lancet* **396**, 1511–1524 (2020).
- Global Report on Urban Health: Equitable Healthier Cities for Sustainable Development* (World Health Organization & UN-Habitat, 2016).
- Healthy Environments for Healthy Children: Key Messages for Action. Report No. 924159988X* (World Health Organization, 2010).
- Report of the Commission on Ending Childhood Obesity* (World Health Organization, 2016).
- Smith, D. M. & Cummins, S. Obese cities: how our environment shapes overweight. *Geogr. Compass* **3**, 518–535 (2009).
- Fraser, B. Latin America’s urbanisation is boosting obesity. *Lancet* **365**, 1995–1996 (2005).
- Pirgon, Ö. & Aslan, N. The role of urbanization in childhood obesity. *J. Clin. Res. Pediatr. Endocrinol.* **7**, 163–167 (2015).

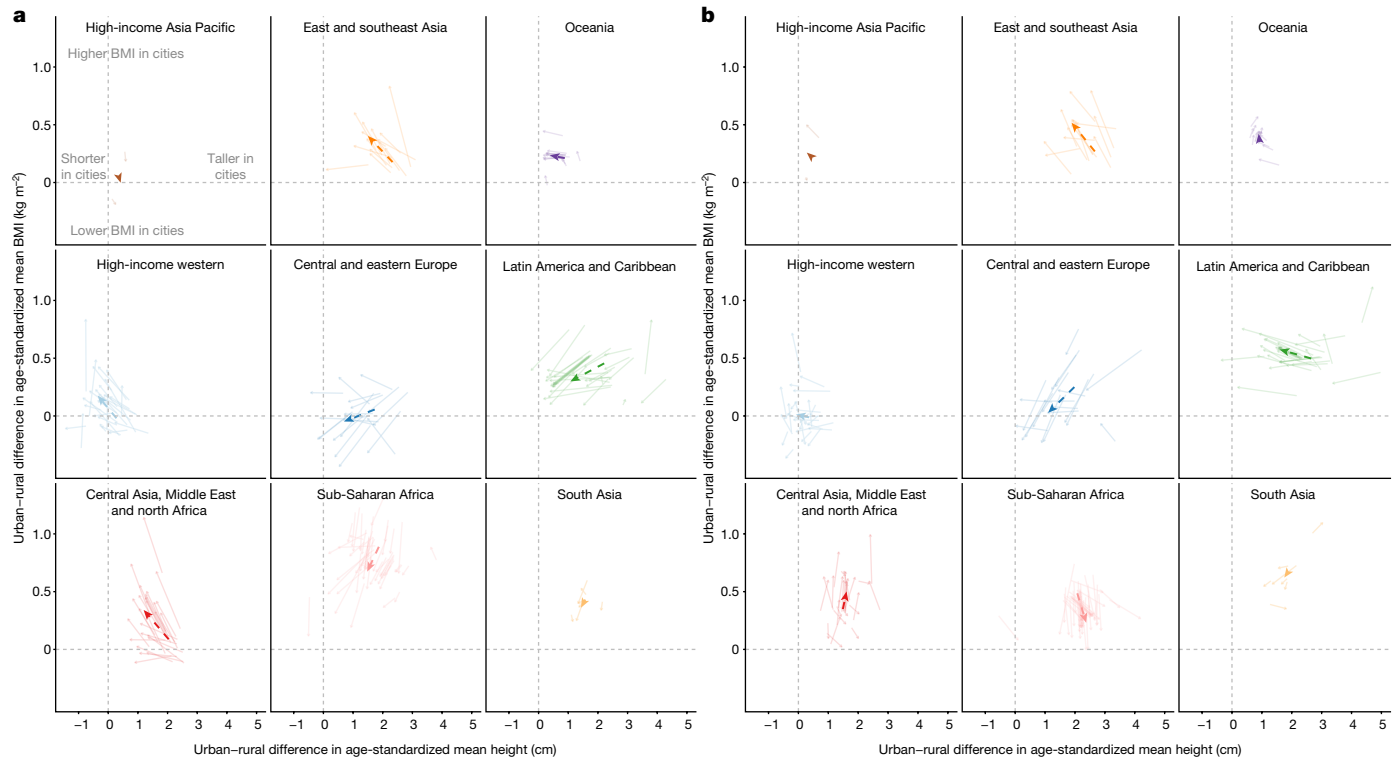


Fig. 7 | Change in the urban-rural height and BMI difference from 1990 to 2020. a, b. Change in the urban-rural difference in age-standardized mean height and the urban-rural difference in age-standardized mean BMI in girls (a) and boys (b). See the caption for Fig. 1 for a description of the contents of

this figure. See Supplementary Fig. 4c for results at ages 5, 10, 15 and 19 years. We did not estimate the difference between rural and urban height and BMI for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau).

14. *The State of the World's Children 2012: Children in an Urban World* (UNICEF, 2012).
15. Kirchengast, S. & Hagmann, D. "Obesity in the city"—urbanization, health risks and rising obesity rates from the viewpoint of human biology and public health. *Hum. Biol. Public Health*, **2**, 1–21 (2021).
16. Congdon, P. Obesity and urban environments. *Int. J. Environ. Res.* **16**, 464 (2019).
17. Gong, P. et al. Urbanisation and health in China. *Lancet* **379**, 843–852 (2012).
18. Liese, A. D., Weis, K. E., Pluto, D., Smith, E. & Lawson, A. Food store types, availability, and cost of foods in a rural environment. *J. Am. Diet. Assoc.* **107**, 1916–1923 (2007).
19. Krumdiek, C. L. The rural-to-urban malnutrition gradient: a key factor in the pathogenesis of urban slums. *JAMA* **215**, 1652–1654 (1971).
20. Paciorek, C. J., Stevens, G. A., Finucane, M. M. & Ezzati, M. Children's height and weight in rural and urban populations in low-income and middle-income countries: a systematic analysis of population-representative data. *Lancet Glob. Health* **1**, e300–e309 (2013).
21. NCD Risk Factor Collaboration (NCD-RisC). Rising rural body-mass index is the main driver of the global obesity epidemic in adults. *Nature* **569**, 260–264 (2019).
22. Jaacks, L. M., Slining, M. M. & Popkin, B. M. Recent trends in the prevalence of under- and overweight among adolescent girls in low- and middle-income countries. *Pediatr. Obes.* **10**, 428–435 (2015).
23. Wang, Y., Monteiro, C. & Popkin, B. M. Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *Am. J. Clin. Nutr.* **75**, 971–977 (2002).
24. Neuman, M., Kawachi, I., Gortmaker, S. & Subramanian, S. V. Urban-rural differences in BMI in low- and middle-income countries: the role of socioeconomic status. *Am. J. Clin. Nutr.* **97**, 428–436 (2013).
25. *Hidden Cities: Unmasking and Overcoming Health Inequities in Urban Settings*. Report No. 9241548037 (World Health Organization & Centre for Health Development, 2010).
26. *Population-based Approaches to Childhood Obesity Prevention*. Report No. 9789241504782 (World Health Organization, 2012).
27. *Prevention of Overweight and Obesity in Children and Adolescents: UNICEF Programming Guidance* (UNICEF, 2019).
28. de Sa, T. H. et al. Urban design is key to healthy environments for all. *Lancet Glob. Health* **10**, e786–e787 (2022).
29. Kelly, C., Callaghan, M., Molcho, M., Nic Gabhainn, S. & Alforque Thomas, A. Food environments in and around post-primary schools in Ireland: associations with youth dietary habits. *Appetite* **132**, 182–189 (2019).
30. Conrad, D. & Capewell, S. Associations between deprivation and rates of childhood overweight and obesity in England, 2007–2010: an ecological study. *BMJ Open* **2**, e000463 (2012).
31. Katsoulis, M. et al. Identifying adults at high-risk for change in weight and BMI in England: a longitudinal, large-scale, population-based cohort study using electronic health records. *Lancet Diabetes Endocrinol.* **9**, 681–694 (2021).
32. Arnett, J. J. Emerging adulthood: a theory of development from the late teens through the twenties. *Am. Psychol.* **55**, 469–480 (2000).
33. Poobalan, A. S., Aucott, L. S., Clarke, A. & Smith, W. C. S. Diet behaviour among young people in transition to adulthood (18–25 year olds): a mixed method study. *Health Psychol. Behav. Med.* **2**, 909–928 (2014).
34. Winpenny, E. M. et al. Changes in diet through adolescence and early adulthood: longitudinal trajectories and association with key life transitions. *Int. J. Behav. Nutr. Phys. Act.* **15**, 86 (2018).
35. Smith, L. C., Ruel, M. T. & Ndiaye, A. Why is child malnutrition lower in urban than in rural areas? Evidence from 36 developing countries. *World Develop.* **33**, 1285–1305 (2005).
36. Lundborg, P., Rooth, D.-O. & Alex-Petersen, J. Long-term effects of childhood nutrition: evidence from a school lunch reform. *Rev. Econ. Stud.* **89**, 876–908 (2022).
37. Graça, P., Gregório, M. J. & Freitas, M. G. A decade of food and nutrition policy in Portugal (2010–2020). *Port. J. Public Health* **38**, 94–118 (2020).
38. Winichagoon, P. Thailand nutrition in transition: situation and challenges of maternal and child nutrition. *Asia Pac. J. Clin. Nutr.* **22**, 6–15 (2013).
39. Paes-Sousa, R. & Vaitsman, J. The Zero Hunger and Brazil without Extreme Poverty programs: a step forward in Brazilian social protection policy. *Cien Saude Colet.* **19**, 4351–4360 (2014).
40. Núñez, J. & Pérez, G. The escape from malnutrition of Chilean boys and girls: height-for-age Z scores in late XIX and XX centuries. *Int. J. Environ. Res. Public Health* **18**, 10436 (2021).
41. Herrmann, R., Möser, A. & Weber, S. A. Grocery retailing in Germany: Situation, development and pricing strategies PDF Logo (Justus-Liebig-Universität Gießen, 2009).
42. Thang, N. M. & Popkin, B. Child malnutrition in Vietnam and its transition in an era of economic growth. *J. Hum. Nutr. Diet.* **16**, 233–244 (2003).
43. Subramanyam, M. A., Kawachi, I., Berkman, L. F. & Subramanian, S. V. Socioeconomic inequalities in childhood undernutrition in India: analyzing trends between 1992 and 2005. *PLoS ONE* **5**, e11392 (2010).
44. Jingzhong, Y. & Lu, P. Differentiated childhoods: impacts of rural labor migration on left-behind children in China. *J. Peasant Stud.* **38**, 355–377 (2011).
45. Sundberg, S. Agriculture, poverty and growth in Africa: linkages and policy challenges. *CABI Rev.* (2009).
46. Bentham, J. et al. Multidimensional characterization of global food supply from 1961 to 2013. *Nat. Food* **1**, 70–75 (2020).
47. Micha, R. et al. Global, regional and national consumption of major food groups in 1990 and 2010: a systematic analysis including 266 country-specific nutrition surveys worldwide. *BMJ Open* **5**, e008705 (2015).

48. Fraval, S. et al. Food access deficiencies in sub-Saharan Africa: prevalence and implications for agricultural interventions. *Front. Sustain. Food Syst.* **3**, 104 (2019).
49. Thomson, M., Kentikelenis, A. & Stubbs, T. Structural adjustment programmes adversely affect vulnerable populations: a systematic-narrative review of their effect on child and maternal health. *Public Health Rev.* **38**, 13 (2017).
50. Frisch, R. E. & Revelle, R. Height and weight at menarche and a hypothesis of critical body weights and adolescent events. *Science* **169**, 397–399 (1970).
51. Holmgren, A. et al. Pubertal height gain is inversely related to peak BMI in childhood. *Pediatr. Res.* **81**, 448–454 (2017).
52. Alhassan, J. A. K., Adeyinka, D. A. & Olakunde, B. O. Equity dimensions of the decline in under-five mortality in Ghana: a joinpoint regression analysis. *Trop. Med. Int. Health* **25**, 732–739 (2020).
53. Wolde, K. S. & Bacha, R. H. Trend and correlates of under-5 mortality in Ethiopia: a multilevel model comparison of 2000–2016 EDHS data. *SAGE Open Med.* **10**, 20503121221100608 (2022).

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2023

Article

NCD Risk Factor Collaboration (NCD-RisC)

Anu Mishra^{1,776}, Bin Zhou^{1,776}, Andrea Rodriguez-Martinez^{1,776}, Honor Bixby^{2,3,776}, Rosie K. Singleton¹, Rodrigo M. Carrillo-Larco¹, Kate E. Sheffer¹, Christopher J. Paciorek⁴, James E. Bennett¹, Victor Lhoste¹, Maria L. C. Iurlilli¹, Mariachiara Di Cesare³, James Benthams⁵, Nowell H. Phelps¹, Marisa K. Sophia¹, Gretchen A. Stevens⁶, Goodarz Danaei⁷, Melanie J. Cowan⁶, Stefan Savin⁶, Leanne M. Riley⁶, Edward W. Gregg¹, Fawhia Aekplakorn⁸, Noor Ani Ahmad⁹, Jennifer L. Baker¹⁰, Adela Chirita-Emandi¹¹, Wischad Farzadfar¹², Günther Fink^{13,14}, Mirjam Heinen¹⁵, Nayu Ikeda¹⁶, Andre P. Kengne¹⁷, Young-Ho Khang¹⁸, Tiina Laatikainen^{19,20}, Avula Laxmaiah²¹, Jun Ma²², Michele Monroy-Valle²³, Malay K. Mridha²⁴, Cristina P. Padez²⁵, Andrew Reynolds²⁶, Maroje Soric^{27,28}, Gregor Starc²⁸, James P. Wirth²⁹, Leandra Abarca-Gómez³⁰, Ziad A. Abdeen³¹, Shynar Abdrakhmanova³², Suhaila Abdul Ghaffar⁹, Hanan F. Abdul Rahim³³, Zulfiya Abdurrahmonova³⁴, Niveen M. Abu-Rmeileh³⁵, Jamila Abubakar Garba³⁶, Benjamin Acosta-Cazares³⁷, Ishaq Adam³⁸, Marzena Adamczyk³⁹, Robert J. Adams⁴⁰, Seth Adu-Afarwah⁴¹, Kaosar Afsana²⁴, Shoaib Afzal^{42,43}, Valérie N. Agbor⁴⁴, Imelda A. Agdeppa⁴⁵, Javad Aghazadeh-Attari⁴⁶, Hassan Aghenaou⁴⁷, Carlos A. Aguilar-Salinas⁴⁸, Charles Agyemang⁴⁹, Mohamad Hasnan Ahmad⁹, Ali Ahmadi⁵⁰, Naser Ahmadi¹², Nastaran Ahmadi⁵¹, Imran Ahmed⁵², Soheir H. Ahmed⁵³, Wolfgang Ahrens⁵⁴, Gulmira Aitmurzayeva⁵⁵, Kamel Ajlouni⁵⁶, Hazzaa M. Al-Hazzaa⁵⁷, Badreya Al-Lahou⁵⁸, Rajaa Al-Raddadi⁵⁹, Huda M. Al Hourani⁶⁰, Nawal M. Al Qaoud⁶¹, Monira Alarouj⁶², Fadia AlBuhairan⁶³, Shahla AlDhukair⁶⁴, Maryam A. Aldwairji⁶¹, Sylvia Alexiuc⁵⁵, Mohamed M. Ali⁶, Abdullah Alkandari⁶², Ala'a Alkerwi⁶⁶, Buthaina M. Alkhatib⁶⁹, Kristine Allin¹⁰, Mar Alvarez-Pedrerol⁶⁷, Eman Aly⁶⁸, Deepak N. Amarapurkar⁶⁰, Pilar Amiano Etchezarreta⁷⁰, John Amoaht⁷¹, Norbert Amougou⁷², Philippe Amouyel^{173,74}, Lars Bo Andersen⁷⁵, Sigmund A. Andersen⁷⁶, Odysseas Androutsos⁷⁷, Lars Ångquist⁴², Ranjit Mohan Anjana⁷⁸, Alireza Ansari-Moghaddam⁷⁹, Elena Anufrieva⁸⁰, Hajer Aounallah-Skhiri⁸¹, Joana Araújo⁸², Inger Ariensen⁸³, Tahir Aris⁸, Raphael E. Arku⁸⁴, Nimmathota Arlappa⁸⁵, Krishna K. Aryal⁸⁵, Nega Aseffa⁸⁶, Thor Aspelund⁸⁷, Felix K. Assah⁸⁸, Baryrbek Assembekov⁸⁹, Maria Cecília F. Assunção⁹⁰, May Soe Ung⁹¹, Juha Auninen⁹², Mária Avidicová⁸⁴, Shina Avy^{95,96}, Ana Azevedo⁹⁷, Mohsen Azimi-Nezhad⁹⁸, Ferreidoun Aziz⁹⁹, Mehرداد Azmin¹², Bontha V. Babu¹⁰⁰, Maja Bæksgaard Jørgensen¹⁰¹, Azli Baharudin⁹, Suhad Bahjiri¹⁰⁰, Marta Bakacs¹⁰², Nagalla Balakrishna²¹, Yulia Balanova¹⁰³, Mohamed Bamoshmooish¹⁰⁴, Maciej Banach¹⁰⁵, José R. Banegas¹⁰⁶, Joanna Baran¹⁰⁷, Rafat Baran¹⁰⁷, Carlo M. Barbagallo¹⁰⁸, Valter Barbosa Filho¹⁰⁹, Alberto Barceló¹¹⁰, Julia Baretic¹¹¹, Amina Barkat¹¹², Joaquin Barnoya¹¹³, Lena Barrera¹¹⁴, Marta Barreto Aluisio J. D. Barros⁹⁰, Mauro Virgílio Gomes Barros¹¹⁷, Anna Bartosiewicz¹⁰⁷, Abdul Basit¹¹⁸, Joao Luiz D. Bastos¹¹⁹, Iqbal Bata¹²⁰, Anwar M. Batieha¹²¹, Aline P. Batista¹²², Rosangela L. Batista¹²³, Zhamilya Battakova³², Louise A. Baur¹²⁴, Pascal M. Bayauli¹²⁵, Robert Beaglehole¹²⁶, Silvia Bel-Serrat¹²⁷, Antonisamy Belavendra¹²⁸, Habiba Ben Romdhane¹²⁹, Judith Benedicis¹³⁰, Mikhail Benet¹³¹, Gilda Estela Benitez Rolandi¹³², Eling Bere¹³³, Ingunn Holden Bergh⁸³, Yemane Berhane¹³⁴, Salim Berkinbayev¹³⁵, Antonio Bernabe-Ortiz¹³⁶, Gailute Bernotiene¹³⁷, Ximena Berríos Carrasola¹³⁸, Heloisa Bettiol¹³⁹, Manfred E. Beute¹⁴⁰, Augustin F. Beybey⁸⁸, Jorge Bezerra¹⁷, Aroor Bhagyalaxmi¹⁴¹, Sumit Bharadwaj¹⁴², Santosh K. Bhargava¹⁴³, Hongsheng Bi¹⁴⁴, Yufang Bi¹⁴⁵, Daniel Bia¹⁴⁶, Katia Biaschi¹⁴⁷, Elysée Claude Bika Lele¹⁴⁸, Mukharram M. Bikbov¹⁴⁹, Bihungum Bista¹⁵⁰, Dusko J. Bjelicja¹⁵¹, Anne A. Bjerregaard¹⁰, Peter Bjerregaard¹⁵², Espen Bjertness⁵³, Marius B. Bjertness⁵³, Cecilia Björkelund¹⁵³, Katia V. Bloch¹⁵⁴, Anneke Blokstra¹⁵⁵, Moran Blychfeld Magnazu^{156,157}, Simona Bo¹⁵⁸, Martin Bobak¹⁵⁹, Lynne M. Boddy¹⁶⁰, Bernhard O. Boehm¹⁶¹, Jolanda M. A. Boer¹⁵⁵, Jose G. Boggia¹⁴⁶, Elena Bogova¹⁶², Carlos P. Boissonnet¹⁶³, Stig E. Bojesen^{43,42}, Marialaura Bonaccio¹⁶⁴, Vanina Bongard¹⁶⁵, Alice Bonilla-Vargas³⁰, Matthias Bopp¹⁶⁶, Herman Borghs¹⁶⁷, Pascal Bove^{168,169}, Khadichamo Boymatova¹⁷⁰, Lien Braeckelvel¹⁷¹, Lutgart Braeckman¹⁷², Marjolijn C. E. Bragt¹⁷³, Imperia Brajkovich¹⁷⁴, Francesco Branca⁶, Juegen Breckenkamp¹⁷⁵, João Breda¹⁷⁶, Hermann Brenner¹⁷⁷, Lizzy M. Brewster⁴⁹, Garry R. Brian¹⁷⁸, Yajaira Briceño¹⁷⁹, Lacamioara Brinduse¹⁸⁰, Miguel Brito¹⁸¹, Sinead Brophy¹⁸², Johannes Brug¹⁵⁵, Graziella Bruno¹⁸³, Anna Bugge¹⁸³, Frank Buntinx¹⁶⁷, Marta Buoncristiano¹⁵, Genc Burazeri¹⁸⁴, Con Burns¹⁸⁵, Antonio Cabrera de León¹⁸⁶, Joseph Cacciottolo¹⁸⁷, Hui Cai¹⁸⁸, Roberta B. Caixeta¹⁸⁹, Tilema Cama¹⁹⁰, Christine Cameron¹⁹¹, José Camolas¹⁹², Günay Can¹⁹³, Ana Paula C. Cândido¹⁹⁴, Felicia Cañete¹³², Mario V. Capanzano⁴⁵, Naděžda Capková¹⁹⁵, Eduardo Capuano¹⁹⁶, Rocco Capuano¹⁹⁶, Vincenzo Capuano¹⁹⁶, Marloes Cardol¹⁹⁷, Viviane C. Cardoso¹⁹⁹, Axel C. Carlsson¹⁹⁸, Esteban Carmuega¹⁹⁹, Joana Carvalho²⁰⁰, José A. Casajús²⁰¹, Felipe F. Casanueva²⁰², Maribel Casas⁶⁷, Ertugrul Celikcan²⁰³, Laura Censi²⁰⁴, Marvin Cervantes-Loaiza³⁰, Juraci A. Cesar²⁰⁵, Snehalatha Chamukuttan²⁰⁶, Angelique Chan²⁰⁷, Queenie Chan¹, Himanshu K. Chaturvedi²⁰⁸, Nish Chaturvedi¹⁵⁹, Norsyamlina Che Abdul Rahim⁹, Miao Li Chee²⁰⁹, Chien-Jen Chen²¹⁰, Fangfang Chen²¹¹, Huashuai Chen²¹², Shuohua Chen²¹³, Zhengming Chen⁴⁴, Ching-Yu Cheng²¹⁴, Yiling J. Cheng²¹⁵, Bahman Cheraghian¹, Angela Chetrit²¹⁷, Ekaterina Chikova-Iscener²¹⁸, Mai J. M. Chinapaw²¹⁹, Anne Chinnock²²⁰, Arnaud Celikcan²⁰³, Shu-Ti Chiou²²², Maria-Dolores Chirlaque²²³, Belong Cho²²⁴, Kaare Christensen²²⁵, Diego G. Christofaro²²⁶, Jerzy Chudek²²⁷, Renata Cifkova^{228,229}, Michelle Cilla²³⁰, Eliza Cinteza¹⁸⁰, Massimo Cirillo²³¹, Frank Claessens¹⁶⁷, Janine Clark²³², Els Clays¹⁷², Emmanuel Cohen⁷², Laura-Maria Compañ-Gabucio²³³, Hans Concina²³⁴, Susana C. Confortin¹²³, Cyrus Cooper²³⁵, Tara C. Coppinger¹⁸⁵, Eva Corpeleijn¹⁸⁷, Lidia Yliria Cortés²³⁶, Simona Costanzo¹⁶⁴, Dominique Cotel²³⁷, Chris Cowell¹²⁴, Cora L. Craig¹⁹¹, Amelia C. Crampin²³⁸, Amanda J. Cross³, Ana B. Crujeiras²³⁹, Juan J. Cruz¹⁰⁶, Tamás Csányi²⁴⁰, Semánová Csilla²⁴¹, Alexandra M. Cucu^{242,243}, Liufu Cui²¹³, Felipe V. Cureau²⁴⁴, Sarah Cuschieri¹⁸⁷, Ewelina Czenczek-Lewandowska¹⁰⁷, Graziella D'Arrigo²⁴⁵, Eleonora d'Orsi¹⁹¹, Liliana Dacica²⁴⁶, Jean Dallongeville²³⁷, Albertino Damasceno²⁴⁷, Camilla T. Damsgaard⁴², Rachel Dankner²¹⁷, Thomas M. Dantoft¹⁰, Parasmani Dasgupta²⁴⁸, Saeed Dastgiri²⁴⁹, Luc Dauchet^{73,74}, Kairat Davletov⁸⁹, Maria Alice Altenburg de Assis¹¹⁹, Guy De Backer¹⁷², Dirk De Bacquer¹⁷², Amalia De Curtis¹⁶⁴, Patricia de Fragas Hinnig¹¹⁹, Giovanni de Gaetano¹⁶⁴, Stefaan De Hennauf¹⁷², Pilar De Miguel-Etayo^{238,201}, Paula Duarte de Oliveira⁹⁰, David De Ridder²⁵⁰, Karin De Ridder²⁵¹, Susanne R. de Rooij^{252,49}, Delphine De Smedt¹⁷², Mohan Deepa⁷⁸, Alexander D. Deev²⁵³, Vincent DeGennaro Jr²⁵⁴, Héliène Delisle²⁵⁵,

Francis Delpeuch²⁵⁶, Stefaan Demarest²⁵¹, Elaine Dennison²³⁵, Katarzyna Dereń¹⁰⁷, Valérie Deschamps²⁵⁷, Meghnath Dhimall¹⁵⁰, Augusto Di Castelnuovo²⁵⁸, Juvenal Soares Dias-da-Costa²⁵⁹, Maria Elena Diaz-Sánchez²⁶⁰, Alejandro Diaz²⁶¹, Pedro Díaz Fernández²⁶², María Pilar Díez Ripollés²⁶³, Zivka Dika²⁷, Shirin Djalalinia²⁶⁴, Vijnja Djordjic²⁶⁵, Ha T. P. Do²⁶⁶, Annette J. Dobson²⁶⁷, Liria Dominguez²⁶⁸, Maria Benedetta Donati⁶⁴, Chiara Donfrancesco²⁶⁹, Guanghui Dong²⁷⁰, Yanhui Dong²², Silvana P. Donoso²⁷¹, Angela Döring²⁷², Maria Dorobantu¹⁸⁰, Ahmad Reza Dorosty²⁷³, Kouamelan Doua²⁷⁴, Nico Dragano²⁷⁵, Wojciech Drygas^{276,105}, Jia Li Duan²⁷⁷, Charmaine A. Duante⁴⁸, Priscilla Duboz²⁷⁸, Vesselka L. Duleva²⁷⁸, Virginija Dulskiene¹³⁷, Samuel C. Dumith²⁰⁵, Anar Dushpanova^{279,280}, Azhar Duyusupova²⁸¹, Vilnis Dzerve²⁸², Elzbieta Dzionkowska-Zaborszczyk¹⁰⁵, Guadalupe Echeverría¹³⁸, Ricky Eddie²⁸³, Ebrahim Eftekhari²⁸⁴, Eruke E. Egbagbe²⁸⁵, Robert Eggertsen¹⁵³, Sareh Eghtesad²⁷³, Gabriele Eiben²⁸⁶, Ulf Ekelund⁷⁶, Mohammed El-Khateeb⁷⁶, Laïla El Ammari²⁸⁷, Jalila El Atti²⁸⁸, Denise Eldemire-Shearer²⁸⁹, Marie Eliassen¹⁰, Paul Elliott¹, Ronit Endevelt^{156,290}, Reina Engle-Stone²⁹¹, Rajiv T. Erasmus²⁹², Raimund Erbel²⁹³, Cihangir Erem²⁸⁴, Gul Ergor²⁹⁵, Louise Erikssen¹⁵², Johan G. Eriksson²⁹⁶, Jorge Escobedo-de la Peña³⁷, Saïed Esлами²⁹⁷, Ali Esmaeil²⁹⁸, Alun Evans²⁹⁹, David Faeh¹⁶⁶, Ildar Fakhradiyev¹³⁵, Albina A. Fakhretdinova¹⁴⁹, Caroline H. Fall²³⁵, Elnaz Faramarzi³⁰⁰, Mojtaba Farjam³⁰¹, Victoria Farrugia Sant'Angelo²³⁰, Mohammad Reza Fattahi³⁰², Asher Fawwad³⁰³, Wafaïe W. Fawzi⁷, Edit Feigl¹⁰², Francisco J. Felix-Redondo³⁰⁴, Trevor S. Ferguson²⁹⁰, Romulo A. Fernandes²²⁶, Daniel Fernández-Bergés³⁰⁵, Daniel Ferrante³⁰⁶, Thomas Ferrao³²², Gerson Ferrari³⁰⁷, Marika Ferrari²⁰⁴, Marco M. Ferrario³⁰⁸, Caterina Ferreccio¹³⁸, Haroldo S. Ferreira³⁰⁹, Eldridge Ferrer⁴⁵, Jean Ferrieres¹⁶⁵, Tamara Hubler Figueiro¹¹⁹, Anna Fijalkowska³¹⁰, Mauro Fisberg³¹¹, Krista Fischer³¹², Leng Huat Foo³¹², Yulia Forsner³¹⁴, Heba M. Fouad⁹⁸, Damian K. Francis²⁸⁹, Maria do Carmo Franco³¹⁵, Zlatko Fras³¹⁶, Guillermo Frontera³¹⁷, Flavio D. Fuchs³¹⁸, Sandra C. Fuchs³¹⁹, Isti I. Fujiati³²⁰, Yuki Fujita³²¹, Matsuda Fumihiko³²², Viktoriya Furdela³²³, Takuro Furusawa³²², Zbigniew Gaciong³²⁴, Mihai Gafencu¹¹, Manuel Galán Cuesta³²⁵, Andrzej Galbarczyk³²⁶, Henrike Galenkamp⁴⁹, Daniela Galeone³²⁷, Myriam Galfo²⁰⁴, Fabio Galvano³²⁸, Jingli Gao²¹³, Pei Gao²², Manoli Garcia-de-la-Hera²²³, Maria José García Mérida²⁶², Marta Garcia Solano²⁹⁹, Dickman Gareta³³⁰, Sarah P. Garnett¹²⁴, Jean-Michel Gaspoz³³¹, Magda Gasul²²³, Adroaldo Cesar Araujo Gaya¹⁹, Anelise Reis Gaya³¹⁹, Andrea Gazzinelli³³², Ulrike Gehring³³³, Harald Geiger²³⁴, Johanna M. Geleijnse³³⁴, Ronnie George³³⁵, Ebrahim Ghaderi³³⁶, Ali Ghanbari¹², Erfan Ghasemi¹², Oana-Florentina Gheorghie-Fronea¹⁸⁰, Alessandro Gialluisi³³⁸, Simona Giampaoli²⁶⁹, Francesco Gianfagna^{308,258}, Christian Gieger²⁷², Tiffany K. Gill³³⁷, Jonathan Giovanniell^{173,74}, Glen Gironella⁴⁵, Aleksander Giwerman³³⁸, Konstantinos Gkiouras³³⁹, Natalya Glushkova^{280,89}, Natalja Gluškova³⁴⁰, Ramesh Godara³⁴¹, Justyna Godos³², Sibel Gogen²⁰³, Marcel Goldberg^{342,343}, David Goltzman², Georgina Gómez²²⁰, Jesús Humberto Gómez Gómez³⁴⁴, Luis F. Gomez²³⁶, Santiago F. Gómez^{345,346}, Aleksandra Gomula³⁴⁷, Bruna Gonçalves Cordeiro da Silva⁹⁰, Helen Gonçalves⁹⁰, Mauer Gonçalves³⁴⁸, Ana D. González-Alvarez³⁴⁹, David A. González-Chica³⁵⁷, Esther M. González-Gil²⁰⁷, Marcela Gonzalez-Gross³⁵⁰, Margot González-Leon³⁷, Juan P. González-Rivas³⁵¹, Clicerio González-Villalpando³⁵², Maria-Elena González-Villalpando³⁵³, Angel R. Gonzalez³⁵⁴, Frederic Gottrand⁷³, Antonio Pedro Graça³⁵⁵, Sidsel Graff-Iversen⁸³, Dušan Grafnetter³⁵⁶, Aneta Grajda³⁵⁷, Maria G. Grammatikopoulou³⁵⁸, Ronald D. Gregor¹²⁰, Maria João Gregório³⁵⁵, Else Karin Grøholt⁶³, Anders Grøntved²²⁵, Giuseppe Grosso³²⁸, Gabriella Gruden¹⁵⁸, Dongfeng Gu³⁵⁹, Viviana Guajardo³⁶⁰, Emanuela Gualdi-Russo³⁶¹, Pilar Guallar-Castillón¹⁰⁶, Andrea Gualtieri³⁶², Elias F. Gudmundsson³⁶³, Vilundur Gudnason⁶⁷, Ramiro Guerrero³⁶⁴, Idris Guessous²⁰, Andre L. Guimaraes³⁶⁵, Martin C. Gulliford³⁶⁶, Johanna Gunnlaugsdottir³⁶³, Marc J. Gunter³⁶⁷, Xiu-Hua Guo³⁶⁸, Yin Guo³⁶⁹, Prakash C. Gupta³⁷⁰, Rajeev Gupta³⁷¹, Oye Gureje³⁷², Enrique Gutiérrez González³²⁹, Laura Gutierrez³⁷³, Felix Gutzwiller¹⁶⁶, Xinyi Gwee²¹⁴, Seongjun Ha³⁷⁴, Farzad Hadaegh³⁷⁵, Charalambos A. Hadjigeorgiou³⁷⁶, Rosa Haghsheenas¹², Hamid Hakim²⁹⁸, Jytte Halkjær³⁷⁷, Ian R. Hambleton³⁷⁸, Behrooz Hamzeh³⁷⁹, Willem A. Hanekom³⁸⁰, Dominique Hange¹⁵³, Abu A. M. Hanif²⁴, Sari Hantunen¹⁹, Jie Hao³⁶⁹, Carla Meneses Hardman³⁸¹, Rachakulla Hari Kumar²¹, Tina Harmer Lassen¹⁰¹, Javhad Haroon³⁸², Seyed Mohammad Hashemi-Shahri⁷⁹, Maria Hassapidou³⁸³, Jun Hata³⁸⁴, Teresa Haugsgjerd³⁸⁵, Alison J. Hayes¹²⁴, Jiang He³⁸⁶, Yuan He³⁸⁷, Yuna He³⁸⁸, Regina Heusinger-Felsö³⁸⁹, Margit Heier²⁷², Tatjana Hejgaard³⁹⁰, Marleen Elisabeth Hendriks³⁹¹, Rafael dos Santos Henrique³⁸¹, Ana Henriques⁸², Leticia Hernandez Cadena³⁵², Sauli Herralta⁹², Marianella Herrera-Cuenca¹⁷⁴, Victor M. Herrera³⁹², Isabelle Herter-Aeberli³⁹³, Karl-Heinz Herzig^{393,92}, Ramin Heshmat³⁹⁴, Allan G. Hill²³⁵, Sai Yin Ho³⁹⁵, Suzanne C. Ho³⁹⁶, Michael Hobbs³⁹⁷, Doroteia A. Höfelmann³⁹⁸, Michelle Holdsworth²⁵⁶, Reza Homayounfar³⁹⁹, Clara Homs^{400,401}, Wilma M. Hopman⁴⁰², Andrea R. V. R. Horimoto¹³⁹, Claudia M. Hormiga⁴⁰³, Bernardo L. Horta⁹⁰, Leila Houti⁴⁰⁴, Christina Howitt³⁷⁶, Thein Thein Htay⁴⁰⁵, Aung Soe Htet⁵³, Maung Maung Than Htike⁴⁰⁶, Yonghua Hu²², José María Huerta²²³, Ilpo Tapani Huhtaniemi¹, Laetitia Huiaut⁴⁰⁷, Constanta Huidumac Petrescu⁴⁴², Martijn Huismans⁴⁰⁸, Abdullahif Hussein³⁵, Chinh Nguyen Huu²⁶⁶, Inge Huybrechts⁴⁰⁷, Nahla Hwalla⁴⁰⁹, Jolanda Hyska¹⁸⁴, Lucia Iacoviello^{164,308}, Ellina M. Iakupova⁴¹⁰, Jesús M. Ibarluzea²³², Mohsen M. Ibrahim⁴¹⁰, Norazizah Ibrahim Wong⁹, M. Arfan Ikram⁴¹¹, Carmen Iñiguez⁴¹², Violeta Iotova⁴¹³, Vilma E. Irazola³⁷³, Takafumi Ishida⁴¹⁴, Godsent C. Isiguzo⁴¹⁵, Muhammad Islam⁴¹⁶, Sheikh Mohammed Shariful Islam⁴¹⁷, Duygu Islek⁴¹⁸, Ivalya Y. Ivanova-Pandouras⁴¹⁹, Masanori Iwasaki⁴²⁰, Tuija Jääskeläinen²⁰, Rod T. Jackson²⁶, Jeremy M. Jacobs⁴²¹, Michel Jadoul⁴²², Tazzen Jafa²⁰⁷, Bakary Jallow⁴²³, Kenneth James²⁸⁹, Kazi M. Jamil⁴²⁴, Konrad Jamrozik^{337,777}, Anna Jansson⁴²⁵, Imre Janszky⁴²⁶, Edward Janus⁴²⁷, Juel Jarani⁴²⁸, Marjo-Riitta Jarvelin⁹³, Grazyna Jasienska³²⁶, Ana Jelaković¹¹¹, Bojan Jelaković²⁷, Garry Jennings⁴²⁹, Chao Qiang Jiang⁴³⁰, Ramon O. Jimenez⁴³¹, Karl-Heinz Jöckel²⁹³, Michel Joffres⁴³², Jari J. Jokelainen⁹², Jost B. Jonas⁴³³, Jitendra Jonnagaddala⁴³⁴, Torben Jörgensen¹⁰, Pradeep Joshi⁴³⁵, Josipa Jospivović¹¹¹, Farahnaz Joukar⁴³⁶, Jacek J. Jóźwiak⁴³⁷, Debra S. Judge³⁹⁷, Anne Juolevi²⁰, Gregor Jural²⁸, Lulia Jurca Simina¹¹, Vesna Juresa²⁷, Rudolf Kaaks¹⁷⁷, Felix O. Kaducu⁴³⁸, Anthony Kafatos⁴³⁹, Mónica Kaj⁴⁴⁰, Eero O. Kajantie²⁰, Natia Kakutia⁴⁴¹, Daniela Kállayová⁴⁴², Zhanna Kalmatayeva²⁸⁰, Ofra Kalter-Leibovici²¹⁷, Yves Kameli²⁵⁶, Freja B. Kampmann¹⁰, Kodanda R. Kanala⁴⁴³, Srinivasan Kannan⁴⁴⁴, Eftymios Kapantais⁴⁴⁵, Eva Karaglani⁴⁴⁶, Argyro Karakosta⁴⁴⁷, Line L. Kärhus¹⁰, Khem B. Karki⁴⁴⁸, Philippe B. Katchunga⁴⁴⁹, Marzieh Katbeh⁴⁵⁰,

Joanne Katz⁴⁵¹, Peter T. Katzmarzyk⁴⁵², Jussi Kauhanen¹⁹, Prabhdeep Kaur⁴⁵³, Maryam Kavousi⁴¹¹, Gylli M. Kazakbaeva¹⁴⁹, François F. Kaze⁸⁸, Calvin Ke⁴⁵⁴, Ulrich Keil⁴⁵⁵, Lital Keinan Boker⁴⁵⁶, Sirkka Keinänen-Kiukaanniemi⁹², Roya Kelishadi⁴⁵⁷, Cecily Kelleher¹²⁷, Han C. G. Kemper²¹⁹, Maryam Keramati²⁹⁷, Alina Kerimkulova⁴⁵⁸, Mathilde Kersting⁴⁵⁹, Timothy Key⁴⁴, Yousef Saleh Khader¹²¹, Arsalan Khalefifar⁴⁶⁰, Davood Khalili³⁹⁹, Kay-Tea Khaw⁴⁶¹, Bahareh Kheiri³⁹⁹, Moteahar Kheradmand⁶², Alireza Khosravi⁴⁶³, Ilse M. S. L. Khoury¹⁷³, Ursula Kiechl-Kohlendorfer⁴⁶⁴, Sophia J. Kiechl⁴⁶⁵, Stefan Kiechl^{464,465}, Japhet Killweo⁴⁶⁶, Hyeon Chang Kim⁴⁶⁷, Jeongseon Kim⁴⁶⁸, Jenny M. Kindblom^{153,469}, Andrew Kingston⁴⁷⁰, Heidi Klakk⁴⁷¹, Magdalena Klimek³²⁶, Jeannette Klombont⁴⁷², Jurate Klumbiene¹³⁷, Michael Knoflach⁴⁶⁴, Bhawesh Koirela⁴⁷³, Elin Koller⁷⁶, Patrick Kolsteren⁷², Jürgen König⁴⁷⁴, Raija Korpelainen⁹³, Paul Korrovits⁴⁷⁵, Magdalena Korzycka³¹⁰, Jelena Kos¹⁴⁰, Seppo Koskinen²⁰, Katsuyasu Kouda⁴⁷⁶, Éva Kovács⁴⁷⁷, Viktoria Anna Kovacs⁴⁴⁰, Irina Kovalsky⁴⁷⁸, Sudhir Kowlessur⁴⁷⁹, Sławomir Koziel³⁴⁷, Jana Kratenova¹⁹⁵, Wolfgang Kratzer⁴⁸⁰, Vilma Krakucioniene¹³⁷, Susi Kriemler¹⁶⁶, Peter Lund Kristensen²²⁵, Helena Krizan⁴⁸¹, Maria F. Kroker-Lobos⁴⁸², Steinar Krokstad⁴²⁶, Daan Kromhout¹⁹⁷, Herculina S. Kruger^{483,484}, Ruan Kruger^{483,484}, Łukasz Kryst⁴⁸⁵, Ruzena Kubinova¹⁹⁵, Renata Kuciene¹³⁷, Urho M. Kujala⁴⁸⁶, Enisa Kujundzić⁴⁸⁷, Zbigniew Kulaga³⁵⁷, Mukhtar Kulimbek^{280,89}, R. Krishna Kumar⁴⁸⁸, Marie Kunesová⁴⁸⁹, Paweł Kurjata²⁷⁶, Yadlapalli S. Kusuma⁴⁹⁰, Vladimir Kutsenko³⁰³, Kari Kulasmaa²⁰, Catherine Kyobutungi⁴⁹¹, Quang Ngoc La⁴⁹², Fatima Zahra Laamiri⁴⁹³, Carl Lachat¹⁷², Karl J. Lachner¹⁴⁰, Youcef Laird⁴⁹⁴, Lachmie Lall⁴⁹⁵, Tai Hing Lam³⁹⁵, Maritza Landaeeta Jimenez⁷⁷⁴, Edwige Landais⁴⁹⁶, Vera Lanska⁴⁹⁶, Georg Lappas⁴⁹⁶, Bagher Larjani⁴⁹⁷, Simo Pone Larissa⁴⁹⁸, Tint Sae Lat⁴⁹⁹, Martino Laurenzi⁵⁰⁰, Laura Lauria²⁶⁹, Maria Lazo-Porrás¹³⁶, Gwenaelle Le Corollé⁴⁹⁶, Khanh Le Nguyen Bao²⁶⁶, Agnès Le Port²⁵⁶, Tuyen D. Le²⁶⁶, Jeannette Lee^{214,501}, Jeonghee Lee⁴⁶⁸, Paul H. Lee⁵⁰², Nils Lehmann²⁹³, Terho Lehtimäki^{503,504}, Daniel Lemogom⁵⁰⁵, Branimir Leskošek²⁸, Justyna Leszczak¹⁰⁷, Katja B. Leth-Mølle¹⁰, Gabriel M. Leung³⁹⁵, Naomi S. Levitt⁵⁰⁶, Yanping Li⁷, Merike Liivak³⁴⁰, Christa L. Lilly⁵⁰⁷, Charlie Lim^{214,501}, Wei-Yen Lim^{214,501}, M. Fernanda Lima-Costa⁵⁰⁸, Hsien-Ho Lin²²², Xu Lin⁵¹⁰, Yi-Ting Lin⁵¹⁰, Lars Lind⁵¹⁰, Vijaya Lingam³³⁹, Birgit Linköer²⁷², Allan Linneberg¹⁰, Lauren Lissner¹⁹³, Mieczysław Litwin³⁵⁷, Jing Liu⁵¹¹, Lijuan Liu³⁶⁹, Wei-Cheng Lo⁵¹², Helle-Mai Loit³⁴⁰, Khuong Quynh Long⁴⁹², Guadalupe Longo Abril¹³³, Luis Lopes²⁰⁰, Marcus V. V. Lopes¹¹⁹, Oscar Lopes⁵¹⁴, Esther Lopez-García¹⁰⁶, Tania Lopez³⁵³, Paulo A. Lotof¹³⁹, José Eugenio Lozano⁵¹⁶, Janice L. Lukrafka⁵¹⁷, Dalia Lukšiene¹³⁷, Annamari Lundqvist²⁰, Nuno Lunet²⁰⁰, Charles Lunogel⁵¹⁸, Michala Lustigová^{228,195}, Edyta Łuszczki¹⁰⁷, Jean-René M'Buyamba-Kabangu⁵¹⁹, Guansheng Ma²², Xu Ma³⁸⁷, George L. L. Machado-Coelho⁷²², Aristides M. Machado-Rodrigues²⁵, Enguerra Macia⁴⁷⁸, Luisa M. Macieira³²⁰, Ahmed A. Madar⁵³, Anja L. Madsen¹⁰, Gladys E. Maestre⁵²¹, Stefania Maggi²²², Dianna J. Magliano⁵²³, Sara Magnacca²⁵⁸, Emmanuelle Magripis⁵²⁴, Gowri Mahasampath¹²⁸, Bernard Maire²⁵⁶, Marjeta Majer²⁷, Marcia Makdisse²²⁵, Päivi Mäki²⁰², Fatemeh Malekzadeh⁴⁷³, Reza Malekzadeh^{302,273}, Rahul Malhotra²⁰⁷, Kodavanti Mallikharjuna Rao²¹, Sofia K. Maluyutina²⁶, Lynell V. Maniego⁴⁶⁵, Yannis Manios⁴⁴⁶, Masimango Imani Manix⁵²⁷, Jim I. Mann²⁶, Fariborz Mansour-Ghanaei⁴³⁶, Taru Manyang⁵²⁸, Enzo Manzato⁵²⁹, Anie Marcell²³², Paula Margozzini¹³⁸, Joany Mariño⁵³⁰, Anastasia Markaki⁵³¹, Onagah Markey⁵³², Eliza Markiddo Ioannidou⁵³³, Pedro Marques-Vidal^{534,535}, Larissa Pruner Marques⁵³⁶, Jaume Marrugat^{537,538}, Yves Martin-Prevel⁵³⁶, Rosemarie Martin⁵³⁹, Reynaldo Martorell⁴¹⁸, Eva Martos⁵⁴⁰, Katarhina Maruszczak⁵⁴¹, Stefano Marventano³²⁸, Giovanna Masala⁵⁴², Luis P. Mascarenhas⁵⁴³, Shariq R. Masoodi⁵⁴⁴, Ellisiv B. Mathiesen⁵⁴⁵, Prashant Mathur⁵⁴⁶, Alicia Matijasevich¹³⁹, Piotr Mattoz¹⁰⁷, Tandi E. Matsuda⁵⁴⁷, Victor Matsudo⁵⁴⁸, Christina Mavrogiani⁴⁴⁶, Artur Mazur¹⁰⁷, Jean Claude N. Mbanya⁵⁴⁸, Shelly R. McFarlane²⁸⁹, Stephen T. McGarvey⁴⁹, Martin McKee⁵⁵⁰, Stela McLachlan⁵⁵¹, Rachael M. McLean²⁶, Scott B. McLean²³², Margaret L. McNairy⁵⁵², Breige A. McNulty¹²⁷, Sounnia Mediene Benchechr⁴⁰⁴, Jurate Medzioniene¹³⁷, Parinaz Mehdipour¹², Kirsten Mehlig¹⁵³, Amir Houshang Mehrparvar⁵¹, Aline Meirhaeghe⁵⁵³, Jørgen Meisjord⁶³, Christa Meisinger²⁷², Jesus D. Melgarejo¹⁶⁷, Marina Melkumova⁵⁵⁴, João Mello³¹⁹, Fabián Méndez²¹⁴, Carlos O. Mendivil⁵⁵⁵, Ana Maria B. Menezes⁹⁰, Geetha R. Menon²⁰⁸, Gert B. M. Mensink⁵⁵⁶, Maria Teresa Menzanc³²⁷, Indrapal I. Meshram²¹, Diane T. Metz⁵⁵⁷, Jie Mi²¹¹, Kim F. Michaelsen⁴², Nathalie Michels¹⁷², Kairit Mikke³¹², Karolina Mitkowska³²⁶, Jody C. Miller³⁵, Olga Milushkina⁵⁵⁸, Cláudia S. Minderico⁵⁵⁹, G. K. Mini⁵⁶⁰, Juan Francisco Miquel¹³⁸, J. Jaime Miranda¹³⁶, Mohammad Reza Mirjalili⁵¹, Daphne Mirkopoulou⁵⁶¹, Erkin Mirrahimov⁴⁵⁸, Marjeta Mišigoj-Duraković²⁷, Antonio Mistretta²²⁸, Veronica Mocanu⁴⁶², Pietro A. Modesti⁵⁶³, Sahar Saeedi Moughaddam¹², Bahram Mohajer¹², Mostafa K. Mohamed⁵⁶⁴, Shukri F. Mohamed⁴⁹¹, Kazem Mohammad²⁷³, Mohammad Reza Mohammad²⁷³, Zahra Mohammad²⁷³, Noushin Mohammadifard⁵⁶⁵, Reza Mohammadpourhodki²⁹⁷, Visvanathan Mohan⁷⁰, Salim Mohanna¹³⁶, Muhammad Fadhli Mohd Yusoff⁹³, Iraj Mohebbi⁴⁶, Farnam Mohebi⁴, Marie Moitry^{147,566}, Line T. Møllehave¹⁰, Niels C. Møller²²⁵, Dénes Molnár³⁸⁹, Amirabbas Momenan³⁹⁹, Charles K. Mondo⁵⁶⁷, Roger A. Montenegro Mendoza⁵⁶⁸, Eric Monterrubio-Flores³⁵², Kotsedi Daniel K. Monyek⁵⁶⁹, Jin Soo Moon⁷²⁴, Mahmood Moosazadeh⁴⁶², Hermine T. Mopa⁸⁸, Farhad Moradpour³³⁶, Leila B. Moreira³¹⁹, Alain Morejon⁵⁷⁰, Luis A. Moreno^{701,239}, Francis Morey³⁷¹, Karen Morgan⁵⁷², Suzanne N. Morin⁷, Erik Lykke Mortensen⁴², George Moschos⁵⁷³, Alireza Moslem⁵⁷⁴, Malgorzata Mossakowska⁵⁷⁵, Aya Mostafa⁵⁶⁴, Seyed-Ali Mostafavi²⁷³, Anabela Mota-Pinto²⁵, Jorge Mota²⁰⁰, Mohammad Esmael Motlagh²¹⁶, Jorge Motta⁵⁶⁸, Marcos André Moura-dos-Santos¹¹⁷, Yeva Movsesyan⁵⁵⁴, Kelias P. Mysamboza⁷⁶, Thet The Mu⁵⁷⁷, Magdalena Muc²⁵⁵, Florian Muca⁵⁷⁸, Boban Mugoša⁴⁸⁷, Maria L. Muiesan⁵⁷⁹, Martina Müller-Nurasyid¹⁴⁰, Thomas Münz¹⁴⁰, Jaakko Mursu¹⁹, Elaine M. Murtagh⁵⁸⁰, Kamarul Imran Musa³¹³, Sanja Musić Milanović^{481,27}, Vera Musi²⁷, Geoffrey Musunguz⁵⁸¹, Muel Telo M. C. Muyer⁵⁸², Iraj Nabipour⁵⁸³, Shohreh Naderimagham¹², Gabriele Nagel⁵⁸⁴, Farid Najafi³⁷⁹, Harunobu Nakamura⁴⁷⁶, Hanna Nalez²⁷⁰, Jana Nešmešná³⁴, Ei Ei K. Nang^{214,501}, Vinay B. Nangia⁵⁸⁵, Martin Nankap⁵⁸⁶, Sameer Naraake³⁷⁰, Paola Nardone⁵⁸⁹, Take Naseri⁵⁸⁷, Matthias Nauck⁵³⁰, William A. Neal⁵⁰⁷, Azim Nejatizadeh²⁸⁴, Chandini Nekkanti⁴³⁴, Keiu Nelis³⁴⁰, Ilona Nenko³²⁶, Martin Neovius⁵⁸⁹, Flavio Nervi¹³⁸, Tze Pin Ng²¹⁴, Chung T. Nguyen⁵⁸⁹, Nguyen D. Nguyen⁵⁹⁰, Quang Ngoc Nguyen⁵⁹¹, Michael Y. Ni³⁹⁵, Rodica Nicolescu²⁴², Peng Nie⁵⁹², Ramfis E. Nieto-Martinez³⁹³, Yury P. Nikitin⁵²⁶, Guang Ning¹⁴⁵, Toshiharu Ninomiya³⁸⁴, Nobuo Nishi¹⁶, Sania Nishtar⁵⁹⁴, Marianna Noale⁵²², Oscar A. Nობოა¹⁴⁶, Helena Nogueira²⁵, Maria Nordendahl³¹⁴, Børge G. Nordestgaard^{43,42}

Davide Noto¹⁰⁶, Natalia Nowak-Szczepanska³⁴⁷, Mohannad Al Nsour⁵⁹⁵, Irfan Nuhoğlu²⁹⁴, Baltazar Nunes^{115,116}, Eha Nurk³⁴⁰, Fred Nuwaha⁵⁸¹, Moffat Nyirenda⁵⁹⁰, Terence W. O'Neill⁵⁹⁶, Dermot O'Reilly²⁹⁹, Galina Obreja⁵⁹⁷, Caleb Ochimana⁷, Angélica M. Ochoa-Avilés²⁷¹, Eiji Oda⁵⁹⁸, Augustine N. Odili⁵⁹⁹, Kyungwon Oh⁶⁰⁰, Kumiko Ohara⁴⁷⁶, Claes Ohlsson^{153,469}, Rytaro Ohtsuka⁶⁰¹, Örn Olafsson³⁶³, Maria Teresa A. Olinto³¹⁹, Isabel O. Oliveira⁹⁰, Mohd Azahad Omar⁶⁰², Saeed M. Omar⁶⁰², Altan Onat^{603,777}, Sok King Ong⁶⁰⁴, N. Charlotte Onland-Moret³³³, Lariane M. Ono³⁹⁸, Pedro Ordunez²⁸⁹, Rui Ornelas⁶⁰⁵, Ana P. Ortiz⁶⁰⁶, Pedro J. Ortiz¹³⁶, Merete Osler¹⁰, Clive Osmond²³⁵, Sergej M. Ostojic²⁶⁵, Afshin Ostovar⁶⁰⁷, Johanna A. Otero⁶⁰⁸, Kim Overvad⁶¹⁰, Ellis Owusu-Dabo⁶⁰⁹, Fred Michel Paccaud¹⁶⁹, Ioannis Paskalos³⁸³, Elena Pahomova²⁸², Karina Mary de Paiva¹¹⁹, Andrzej Pajak²²⁶, Alberto Palloni⁶¹⁰, Luigi Palmieri²⁶⁹, Wen-Harn Pan⁷¹⁰, Songhomitra Panda-Jonas⁵¹¹, Arvind Pandey²⁰⁸, Francesco Panza⁶¹², Mariela Paoli¹⁷⁹, Sousana K. Papadopoulou³⁸³, Dimitrios Papanadreou⁶¹³, Rossina G. Pareja²⁶⁸, Soon-Woo Park⁶¹⁴, Suyeon Park⁶⁰⁰, Winsome R. Parnell²⁶⁷, Mahboubeh Parsaeian²⁷³, Inela M. Pascanu⁶¹⁵, Patrick Pasquet²⁷, Nikhil D. Patel⁶¹⁶, Marcos Pattuss²⁵⁹, Halyna Pavlyshyn²²³, Raimund Pechlauer⁶¹⁴, Ivan Pećin¹¹¹, Mangesh S. Pednekar³⁷⁰, João M. Pedro⁶¹⁷, Nasheeta Peer⁶¹⁸, Sergio Viana Peixoto⁵⁰⁸, Markku Peltonen²⁰, Alexandre C. Pereira¹³⁹, Marco A. Peres⁶¹⁹, Cynthia M. Pérez⁶⁰⁶, Valentina Peterkova¹⁶², Annette Peters²⁷², Astrid Petersmann³³⁰, Janina Petkeviciene¹³⁷, Austra Petrauskienė¹³⁷, Olga Petrovna Kovtun⁸⁰, Emanuela Pettenuzzo⁶²⁰, Niloofar Peykari²⁶⁴, Norbert Pfeiffer¹⁴⁰, Modou Cheyassan Phall⁴²³, Son Thai Pham⁶²¹, Rafael N. Pichardo⁶²², Daniela Pierannunzio²⁶⁹, Iris Pigeot⁵⁴, Hynke Pikhart¹⁵⁹, Aida Pilav⁶²³, Lorenza Pilotto⁶²⁴, Francesco Pistelli⁶²⁵, Freda Pitakak⁶²⁶, Aleksandra Piwońska²⁷⁶, Andrea N. Pizarro²⁰⁰, Pedro Plans-Rubió⁶²⁷, Alina G. Platonova⁶²⁸, Bee Koon Poh⁶²⁹, Herrmann Pohlhaas⁶³⁴, Nadjia S. Polka⁶²⁸, Raluca M. Pop⁶¹⁵, Stevo R. Popovic¹⁵¹, Miquel Porta³³⁸, Georg Posch²³⁴, Anil Poudyal¹⁵⁰, Dimitrios Poulimeneas³⁸³, Hamed Pouraram²⁷³, Farhad Pourfarzi⁶³⁰, Akram Pourshams²⁷³, Hossein Poustchi²⁷³, Rajendra Pradeepa⁷⁸, Alison J. Price⁵⁰, Jacqueline F. Price⁵¹, Antonio Prista⁶³¹, Rui Providencia¹⁵⁹, Jardena J. Puder³³⁴, Iveta Pudule⁶³², Maria Puiu¹¹, Margaryunat⁴⁷⁵, Muhammed S. Qadir⁶³³, Radwan F. Qasrawi¹³¹, Mostafa Qorbani⁶³⁴, Hedley K. Quintana⁵⁶⁸, Pedro J. Quiroga-Padilla⁵⁶⁵, Tran Quoc Bao⁵³⁵, Stefan Rach⁵⁴, Ivana Radic²⁶⁵, Ricardas Radisauskas¹³⁷, Salar Rahimikazeroni³⁰², Mahfuzar Rahman⁶³⁶, Mahmudur Rahman⁵³⁷, Olli Raitakar⁶³⁸, Manu Raj⁴⁸⁸, Tamerlan Rajabov⁶³⁹, Sherali Rakhmatulloev³⁴, Ivo Rakovac¹⁵, Suda Ramachandra Rao⁴⁵³, Ambady Ramachandran²⁰⁶, Otim P. C. Ramadan⁶⁴⁰, Virgílio V. Ramires⁶⁴¹, Jacqueline Ramke¹²⁶, Elisabete Ramos⁹⁷, Rafael Ramos⁶⁴², Lekhraj Rampal⁶⁴³, Sanjay Rampal⁶⁴⁴, Lalka S. Rangelova²¹⁸, Vayia Rarra⁶⁴⁵, Ramon A. Rascon-Pacheco³⁷, Cassiano Ricardo Rech¹¹⁹, Josep Redon⁴¹², Paul Ferdinand M. Regani⁶⁴⁶, Valéria Regecová⁶⁴⁷, Jane D. P. Renner⁶⁴⁸, Judith A. Repeny³⁸⁹, Cézaue P. Reuter⁶⁴⁸, Luis Revilla¹⁵, Abbas Rezaizadeh³⁰², Yeunsook Rho³⁷⁴, Lourdes Ribas-Barba⁶⁴⁹, Robespierre Ribeiro^{650,777}, Elio Riboli¹, Adrian Richter⁵³⁰, Fernando Rigo⁶⁵¹, Attilio Rigotti¹³⁸, Natascia Rinaldo³⁶¹, Tobias F. Rinke de Wit⁸⁵², Ana I. Rito¹¹⁵, Raphael M. Ritti-Dias⁶⁵³, Juna A. Rivera³⁵², Reina G. Roa⁶⁵⁴, Louise Robinson⁷⁰, Cynthia Robitaille⁶⁵⁵, Romana Roccaldo²⁰⁴, Daniela Rodrigues²⁵, Fernando Rodriguez-Artalejo¹⁰⁶, Maria del Cristo Rodriguez-Perez²⁶², Laura A. Rodriguez-Villamizar⁶⁵⁶, Andrea Y. Rodriguez⁶⁵⁷, Ulla Roggenbuck²⁹³, Peter Rohloff⁶⁵⁸, Fabian Rohner⁵⁹⁵, Rosalba Rojas-Martinez³⁵², Nipa Rojroongwasinkul⁸, Dora Romaguera²³⁹, Elisabetta L. Romeo⁶⁶⁰, Rafaela V. Rosario⁶⁶¹, Annika Rosengren^{153,469}, Ian Rouse⁶⁶², Vanessa Rouzier⁶⁶³, Joel G. R. Roy³²³, Maira H. Ruano⁶⁶⁴, Adolfo Rubinstein³⁷³, Frank J. Ruhl¹⁶⁶, Jean-Bernard Ruidavets¹⁶⁵, Blanca Sandra Ruiz-Betancourt³⁷, María Ruiz-Castell⁶⁶, Emma Ruiz Moreno⁶⁶⁵, Iuliia A. Rusakova¹⁴⁹, Kenisha Russell Jonsson⁴²⁵, Paola Russo⁶⁶⁶, Petra Rust⁴⁷⁴, Marcin Rutkowski⁶⁶⁷, Marge Saamel³⁴⁰, Charumathi Sabanayagam²⁰⁹, Hamideh Sabbaghi³⁹⁹, Elena Sacchin³⁶², Harshpal S. Sachdev⁶⁶⁸, Alireza Sadjad²⁷³, Ali Reza Safarpour³⁰², Sare Safi²⁹⁹, Saied Safiri²⁰⁰, Mohammad Hossien Saggi⁵⁷⁴, Olfa Saidi¹²⁹, Nader Sak²¹⁶, Sanja Šalaž²⁷, Benoit Salanave²⁵⁷, Eduardo Salazar Martínez³⁹², Calogero Saleva⁵⁴², Diego Salmerón²²³, Veikko Salomaa²⁰, Jukka T. Salonen²⁹⁶, Massimo Salvetti⁵⁷⁹, Margarita Samoutina⁶⁶⁹, Jose Sánchez-Abanto⁶⁷⁰, Inés Sánchez Rodríguez³⁴⁴, Sandjaja⁶⁷¹, Susana Sans⁶⁷², Loreto Santa Marina⁶⁷³, Ethel Santoro¹³², Diana A. Santos⁵⁵⁹, Ina S. Santos⁹⁰, Lèlita C. Santos⁵²⁰, Maria Paula Santos²⁰⁰, Osvaldo Santos⁶⁷⁴, Rute Santos²⁰⁰, Tamara R. Santos⁶⁷⁵, Jouko L. Saramies⁶⁷⁶, Luis B. Sardinha⁶⁷⁶, Nizal Sarrafzadegan⁶⁷⁷, Thirunavukarasu Sathish⁴¹⁸, Kai-Uwe Saum¹⁷⁷, Savvas Savva⁷⁶, Mathilde Savy²⁶⁶, Norie Sawada⁶⁷⁷, Mariana Sbaraini³¹⁹, Marcia Sczufca⁶⁷⁸, Beatriz D. Schaan³¹⁹, Angelika Schaffrath Rosario²⁰, Herman Schargrodsky⁶⁷⁹, Anja Schienkiewitz⁵⁵⁶, Karin Schindler⁶⁸⁰, Sabine Schipf³³⁰, Carsten O. Schmidt³⁰, Ida Maria Schmidt⁶⁸¹, Andrea Schneider²⁷², Peter Schnohr⁴³, Ben Schöttker¹⁷⁷, Sara Schramm²⁶³, Stine Schramm²²⁵, Helmut Schröder²²³, Constance Schultz⁶⁸², Matthias B. Schulze⁶⁸³, Aletta E. Schutte^{434,684}, Sylvain Sebert⁹³, Moslem Sedaghattalab³⁸², Rusidah Selamat⁹, Vedrana Sember²⁸, Abhijit Sen⁶⁸⁵, Idowu O. Senbanjo⁶⁸⁶, Sadaf G. Sepanlou²⁷³, Guillermo Sequeira¹³², Luis Serra-Majem⁶⁸⁷, Jennifer Servais³²², Ludmila Ševčíková⁶⁸⁸, Svetlana Shalnova¹⁰³, Teresa Shamah-Levy³⁵², Seyed Morteza Shamshegar⁹⁸, Coimbatore Subramaniam Shanthirani⁷⁸, Maryam Sharafkhan²⁷³, Sanjib K. Sharma⁴⁷³, Jonathan E. Shaw²²³, Amaneh Shayanard²⁷³, Ali Akbar Shayesteh²¹⁶, Lela Shengelia⁴¹¹, Zumin Shi³³, Kenji Shibuya⁶⁸⁶, Hana Shimizu-Furusawa⁶⁸⁹, Tal Shimony⁶⁹⁰, Rahman Shir⁶⁹⁰, Namuna Shrestha⁸⁵, Khairil Si-Ramlee⁶⁰⁴, Alfonso Siani⁶⁶⁶, Rosalynn Siantar²⁰⁹, Abba M. Sibai⁴⁰⁹, Labros S. Sidossis⁹¹, Natalia Siltrani⁶⁹², Antonio M. Silva²²³, Caroline Ramos de Moura Silva¹¹⁷, Diego Augusto Santos Silva¹¹⁹, Kelly S. Silva¹¹⁹, Xueling Sim^{214,501}, Mary Simon²⁰⁶, Judith Simons⁶⁹³, Leon A. Simons⁴³⁴, Agneta Sjöberg¹⁵³, Michael Sjöström^{688,777}, Natalia A. Skoblina⁵⁵⁹, Gry Skodje⁶⁹⁴, Tatyana Slazhnyova², Jolanta Stojkowska-Hilczek¹⁰⁵, Przemysław Słusarczyk⁵⁷⁵, Liam Smeeth⁵⁵⁰, Hung-Kwan So³⁹⁵, Fernanda Cunha Soares¹¹⁷, Grzegorz Sobek¹⁰⁷, Eugène Sobngwi⁸⁸, Morten Sodemann²²⁵, Stefan Söderberg³¹⁴, Moesijanti Y. E. Soekati⁶⁹⁵, Augustinus Soemantri^{696,777}, Reecha Sofat¹⁵⁹, Vincenzo Solfrizzi⁶⁹⁷, Mohammad Hossein Somi³⁰⁰, Emily Sonestedt³³⁸, Yi Song²², Sajid Soofi⁵², Thorkild I. A. Sørensen⁴², Elin P. Sörgjerd⁴²⁶, Charles Sossa Jérôme⁶⁹⁸, Victoria E. Soto-Rojas⁶⁸⁴, Aicha Soumaré⁶⁹⁹, Alfonso Sousa-Poza⁷⁰⁰, Slavica Sovic²⁷, Bente Sparboe-Nilsen⁷⁰¹, Karen Sparrenberger³¹⁹, Phoebe R. Spencer³⁹⁷, Angela Spinelli²⁶⁹, Igor Spiroski^{702,703}, Jan A. Staessen¹⁶⁷, Hanspeter Stamm⁷⁰⁴, Kaspar Staub¹⁶⁶, Bill Stavreski⁴²⁹, Jostein Steene-Johannessen⁷⁶, Peter Stehle⁷⁰⁵, Aryeh D. Stein⁴¹⁸, George S. Stergiou⁴⁴⁷

Article

Jochanan Stessman⁴²¹, Ranko Stevanović⁴⁸¹, Jutta Stieber^{272,777}, Doris Stöckl²⁷², Jakub Stokwiszewski⁷⁰⁶, Ekaterina Stoyanova⁷⁰⁷, Gareth Stratton¹⁸², Karien Stronks⁴⁹, Maria Wany Strufaldi³⁹⁵, Lela Sturua⁴⁴¹, Ramón Suárez-Medina²⁶⁰, Machi Suka⁷⁰⁸, Chien-An Sun⁷⁰⁹, Liang Sun⁵⁰⁹, Johan Sundström⁵¹⁰, Yn-Tz Sung³⁹⁶, Jordi Sunyer⁶⁷, Raibul Suriyawongpaisal⁸, Nabil William G. Sweis⁷¹⁰, Boyd A. Swinburn¹²⁶, Rody G. Sy⁴⁴⁶, René Charles Sylva⁷¹¹, Moyes Szkló⁴⁵¹, Lorraine Szponar⁷⁰⁶, Lorraine Tabone²³⁰, E. Shyong Tai^{214,501}, Konstantinos D. Tambalakis⁴⁴⁷, Mari-Liis Tammeo³¹², Abdonas Tamosiunas¹³⁷, Eng Joo Tan²², Xun Tang²², Maya Tanrygulyeva⁷¹³, Frank Tanser⁷¹⁴, Yong Tao²², Mohammed Rasoul Taraneh⁷¹⁵, Jakob Tarp⁴⁵⁰, Carolina B. Tarquí-Mamani⁶⁷⁰, Radka Taxová Braunerová⁴⁸⁹, Anne Taylor³³⁷, Julie Taylor¹⁵⁹, Félicité Tchibindat⁷¹⁶, Saskia Te Velde⁷¹⁷, William R. Tebar²²⁶, Grethe S. Tell³⁸⁵, Tania Tello¹³⁶, Yih Chung Tham²⁰⁹, K. R. Thankappan³⁴¹, Holger Theobald¹⁹⁸, Xenophon Theodoridis³³⁹, Nihal Thomas²⁵⁸, Barbara Thorand²⁷², Betina H. Thuesen¹⁰, Lubica Tichá⁶⁸⁸, Erik J. Timmermans⁷¹⁸, Dwi H. Tjandrarini⁷¹⁹, Anne Tjønneland³⁷⁷, Hanna K. Tolonen²⁰, Janne S. Tolstrup¹⁵², Murat Topbas²⁹⁴, Roman Topór-Mądry³²⁶, Liv Elin Torheim⁷⁰¹, María José Toranzo⁷²⁰, Michael J. Tornaritis³⁷⁶, Maties Torrent⁷²¹, Laura Torres-Collado⁷²³, Stefania Toselli⁷²², Giota Touloumi¹⁴⁷, Pierre Traissac²⁵⁶, Thi Tuyet-Hanh Tran⁴⁹², Mark S. Tremblay⁷²³, Arethi Triantafyllou³³⁹, Dimitrios Trichopoulos⁵⁷⁷⁷, Antonia Trichopoulou⁷²⁴, Oanh T. H. Trinh⁵⁹⁰, Atul Trivedi⁷²⁵, Yu-Hsiang Tsoo⁷²⁶, Lechaba Tshupo⁷²⁷, Maria Tsigga³⁸³, Panagiotis Tsintavis³⁸³, Shoichiro Tsugane⁶⁷⁷, John Tuitele^{728,729}, Azalia M. Tuliakova¹⁴⁹, Marshall K. Tulloch-Reid²⁸⁹, Fikru Tullu³³⁰, Tomi-Pekka Tuomainen¹⁹, Jaakko Tuomilehto²⁰, Maria L. Turley⁷³¹, Gilad Twig^{273,732}, Per Tynelius⁵⁸⁸, Evangelia Tzala¹, Themistoklis Tzotzas⁴⁴⁵, Christophe Tzourio⁶⁹⁹, Peter Ueda⁴, Eunice Ugel³³, Flora A. M. Ukoli⁷³⁴, Hanno Ulmer⁴⁶⁴, Belgin Unal²⁹⁵, Zhamilya Usupova⁵⁹⁵, Hannu M. T. Uusitalo⁷³⁵, Nalan Uysal⁷³⁶, Justina Vaitkeviciute¹³⁷, Gonzalo Valdívia³³⁸, Susana Vale⁷³⁷, Damaskini Valvi⁷³⁸, Rob M. van Dam⁷³⁹, Bert-Jan van den Born⁴⁹, Johan Van der Heyden²⁵¹, Yvonne T. van der Schouw³³³, Koen Van Herck¹⁷², Wendy Van Lippevelde¹⁷², Hoang Van Minh⁴⁹², Natasja M. Van Schoor⁴⁰⁸, Irene G. M. van Valkengoed⁴⁹, Dirk Vanderschueren¹⁶⁷, Diego Vanuzzo⁶²⁴, Anette Varbo^{43,42}, Gregorio Varela-Moreiras⁷⁴⁰, Lix Nayibe Vargas²³⁶, Patricia Varona-Pérez²⁶⁰, Senthil K. Vasan²³⁵, Daniel G. Vasques³¹⁸, Tomas Vega⁵¹⁶, Toomas Veidebaum³⁴⁰, Gustavo Velasquez-Melendez³³², Biruta Velika⁶³², Maité Verloigne¹⁷², Giovanni Veronesi³⁰⁹, W. M. Monique Verschuren¹⁵⁵, Cesar G. Victora⁹⁰, Giovanni Vieti⁷⁶¹, Lucie Viet¹⁸⁵, Freydis N. Vil¹³⁹, Monica Vilar⁷⁴², Salvador Villalpando³⁵², Jesus Vioque⁷⁴³, Jyrki K. Virtanen¹⁹, Sophie Visvikis-Siest⁷⁴⁴, Bharathi Viswanathan¹⁶⁸, Mihaela Vladulescu⁷⁴⁵, Tiina Vlasoff⁷⁴⁶, Dorja Vocanec²⁷, Peter Vollenweider^{534,535}, Henry Völzke⁵³⁰, Ari Voutilainen¹⁶, Martine Vrijheid⁶⁷, Tanja G. M. Vrijkotte^{252,49}, Alisha N. Wade⁷⁴⁷, Thomas Waldhór⁶⁸⁰, Janette Walton¹⁸⁵, Elvis O. A. Wambiya⁴⁹¹, Wan Mohamad Wan Bekar³¹², Wan Nazaimoon Wan Mohamad⁷⁴⁸, Rildo de Souza Wanderley Júnior¹⁷, Ming-Dong Wang⁶⁵⁵, Ningli Wang²⁶⁹, Qian Wang⁷⁴⁹, Xiangjun Wang⁷⁵⁰, Ya Xing Wang³⁶⁸, Ying-Wei Wang⁷⁵¹, S. Gory Wannamethee¹⁵⁹, Nicholas Wareham⁴⁶¹, Adelheid Weber¹³⁰, Karen Webster-Kerr⁷⁵², Niels Wedderkopp²²⁵, Daniel Weghuber⁵⁴¹, Wenbin Wei³⁶⁸, Aneta Weres¹⁰⁷, Bo Werner⁷⁵³, Leo D. Westbury²³⁵, Peter H. Whincup⁷⁵⁴, Kremlin Wickramasinghe¹⁵, Kurt Widhalm⁶⁸⁰, Indah S. Widyahening⁷⁵⁵, Andrzej Więcek²²⁷, Philipp S. Wild¹⁴⁰, Rainford J. Wilks²⁸⁹, Johann Willeit⁴⁶⁴, Peter Willeit⁴⁶⁴, Julianne Williams¹⁵, Tom Wilsaard⁴⁹⁵, Rusek Wojciech⁷⁵⁶, Bogdan Wojtyniak⁷⁰⁶, Kathrin Wolf²⁷², Roy A. Wong-McClure³⁰, Andrew Wong¹⁵⁹, Emily B. Wong³⁸⁰, Jyh Eiin Wong⁶²⁹, Tien Yin Wong²⁰⁷, Jean Woo³⁹⁶, Mark Woodward¹⁴³⁴, Frederick C. Wu⁵⁰⁶, Hon-Yen Wu⁷⁵⁷, Jianfeng Wu¹⁴⁴, Li Juan Wu³⁶⁸, Shouling Wu²¹³, Justyna Wyszynska¹⁰⁷, Haiquan Xu⁷⁵⁸, Liang Xu⁷⁵⁹, Nor Azwany Yaacob³¹³, Uruwan Yamborisut⁸, Weili Yan⁷⁶⁰, Ling Yang⁴⁴, Xiaoguang Yang³⁸⁸, Yang Yang⁷⁵⁰, Nazan Yardim²⁰³, Tabara Yasuharu²²², Maria Yépez García⁷⁴², Panayiotis K. Yiallouris⁷⁶¹, Agneta Yngve³¹⁰, Moein Yoosofi¹², Akihiro Yoshihara⁷⁶², Qi Sheng You³⁶⁸, San-Lin You⁷⁰⁹, Novie O. Younger-Coleman²⁸⁹, Yu-Ling Yu¹⁶⁷, Yunjiang Yu⁷⁶³, Safiah Md Yusof⁶⁴, Ahmad Faudzi Yusoff⁹, Luciana Zaccagni³⁶¹, Vassilis Zafiroputos⁷⁶⁵, Ahmad A. Zainuddin⁷¹, Seyed Rasoul Zakavi²⁹⁷, Farhad Zamani⁷⁶⁶, Sabina Zambon⁵²⁹, Antonis Zampelas⁵²⁴, Hana Zamrazilová⁴⁸⁹, Maria Elisa Zapata¹⁹⁹, Abdul Hamid Zargar⁷⁶⁷, Ko Ko Zaw⁴⁹⁹, Ayman A. Zayed⁷¹⁰, Tomasz Zdrojewski⁶⁶⁷, Magdalena Zęgleń⁷⁶⁸, Kristyna Zegljkovic⁹⁵, Tajana Zeljkovic Vrkić¹¹, Yi Zeng^{22,769}, Luxia Zhang⁷⁷⁰, Zhen-Yu Zhang¹⁶⁷, Dong Zhao⁵¹¹, Ming-Hui Zhao⁷⁷⁰, Wenhua Zhao³⁸⁸, Yanita V. Zhecheva⁴¹⁹, Shiqi Zhen⁷⁷¹, Wei Zheng¹⁸⁸, Yingfeng Zheng⁷⁷⁰, Bekbolat Zholdin⁷⁷², Maigeng Zhou³⁸⁸, Dan Zhu⁷⁷³, Marie Zins^{342,343}, Emanuel Zitt²³⁴, Yanina Zocalo¹⁴⁶, Nada Zoghalmi⁸¹, Julio Zuñiga Cisneros⁵⁶⁸, Monika Zuziak⁷⁷⁴, Zulfiqar A. Bhutta^{416,52}, Robert E. Black⁷⁷⁵ & Majid Ezzati^{1,41,623}

Rzeszów, Poland. ⁴⁰Flinders University, Adelaide, South Australia, Australia. ⁴¹University of Ghana, Accra, Ghana. ⁴²University of Copenhagen, Copenhagen, Denmark. ⁴³Copenhagen University Hospital, Copenhagen, Denmark. ⁴⁴University of Oxford, Oxford, UK. ⁴⁵Food and Nutrition Research Institute, Taguig, The Philippines. ⁴⁶Urmia University of Medical Sciences, Urmia, Iran. ⁴⁷Ibn Tofail University, Kénitra, Morocco. ⁴⁸Instituto Nacional de Ciencias Médicas y Nutrición, Mexico City, Mexico. ⁴⁹University of Amsterdam, Amsterdam, The Netherlands. ⁵⁰Modeling in Health Research Center, Shahrekord, Iran. ⁵¹Shahid Sadoughi University of Medical Sciences, Yazd, Iran. ⁵²The Aga Khan University, Karachi, Pakistan. ⁵³University of Oslo, Oslo, Norway. ⁵⁴Leibniz Institute for Prevention Research and Epidemiology-BIPS, Bremen, Germany. ⁵⁵Republican Center for Health Promotion, Bishkek, Kyrgyzstan. ⁵⁶National Center for Diabetes, Endocrinology and Genetics, Amman, Jordan. ⁵⁷Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia. ⁵⁸Kuwait Institute for Scientific Research, Kuwait City, Kuwait. ⁵⁹King Abdulaziz University, Jeddah, Saudi Arabia. ⁶⁰The Hashemite University, Zarqa, Jordan. ⁶¹Ministry of Health, Kuwait City, Kuwait. ⁶²Dasman Diabetes Institute, Kuwait City, Kuwait. ⁶³Aldara Hospital and Medical Center, Riyadh, Saudi Arabia. ⁶⁴King Abdullah International Medical Research Center, Riyadh, Saudi Arabia. ⁶⁵Universidade Federal da Integração Latino-Americana, Foz do Iguaçu, Brazil. ⁶⁶Luxembourg Institute of Health, Strassen, Luxembourg. ⁶⁷Barcelona Institute for Global Health CIBERESP, Barcelona, Spain. ⁶⁸World Health Organization Regional Office for the Eastern Mediterranean, Cairo, Egypt. ⁶⁹Bombay Hospital and Medical Research Centre, Mumbai, India. ⁷⁰Departamento de Salud del Gobierno Vasco, San Sebastián, Spain. ⁷¹Ghana Health Service, Kintampo, Ghana. ⁷²UMR CNRS-MNHN 7206, Paris, France. ⁷³University of Lille, Lille, France. ⁷⁴Lille University Hospital, Lille, France. ⁷⁵Western Norway University of Applied Sciences, Sogndal, Norway. ⁷⁶Norwegian School of Sport Sciences, Oslo, Norway. ⁷⁷University of Thessaly, Trikala, Greece. ⁷⁸Madras Diabetes Research Foundation, Chennai, India. ⁷⁹Zahedan University of Medical Sciences, Zahedan, Iran. ⁸⁰Yekaterinburg State Medical Academy, Yekaterinburg, Russia. ⁸¹National Institute of Public Health, Tunis, Tunisia. ⁸²Institute of Public Health of the University of Porto, Porto, Portugal. ⁸³Norwegian Institute of Public Health, Oslo, Norway. ⁸⁴University of Massachusetts Amherst, Amherst, MA, USA. ⁸⁵Public Health Promotion and Development Organization, Kathmandu, Nepal. ⁸⁶Haramaya University, Dire Dawa, Ethiopia. ⁸⁷University of Iceland, Reykjavik, Iceland. ⁸⁸University of Yaoundé 1, Yaoundé, Cameroon. ⁸⁹Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan. ⁹⁰Federal University of Pelotas, Pelotas, Brazil. ⁹¹University of Medicine 1, Yangon, Myanmar. ⁹²Oulu University Hospital, Oulu, Finland. ⁹³University of Oulu, Oulu, Finland. ⁹⁴Regional Authority of Public Health, Banská Bystrica, Slovakia. ⁹⁵Tel Aviv University, Tel Aviv, Israel. ⁹⁶Hebrew University of Jerusalem, Jerusalem, Israel. ⁹⁷University of Porto Medical School, Porto, Portugal. ⁹⁸Neyshabur University of Medical Sciences, Neyshabur, Iran. ⁹⁹Research Institute for Endocrine Sciences, Tehran, Iran. ¹⁰⁰Indian Council of Medical Research, New Delhi, India. ¹⁰¹National Institute of Public Health, Copenhagen, Denmark. ¹⁰²National Institute of Pharmacy and Nutrition, Budapest, Hungary. ¹⁰³National Medical Research Centre for Therapy and Preventive Medicine, Moscow, Russia. ¹⁰⁴University of Science and Technology, Sana'a, Yemen. ¹⁰⁵Medical University of Lodz, Lodz, Poland. ¹⁰⁶Universidad Autónoma de Madrid CIBERESP, Madrid, Spain. ¹⁰⁷University of Rzeszów, Rzeszów, Poland. ¹⁰⁸University of Palermo, Palermo, Italy. ¹⁰⁹Federal Institute of Education, Science and Technology of Ceara, Ceara, Brazil. ¹¹⁰University of Miami, Miami, FL, USA. ¹¹¹University Hospital Center Zagreb, Zagreb, Croatia. ¹¹²Mohammed V University, Rabat, Morocco. ¹¹³Unidad de Cirugía Cardiovascular, Guatemala City, Guatemala. ¹¹⁴Universidad del Valle, Cali, Colombia. ¹¹⁵National Institute of Health Doutor Ricardo Jorge, Lisbon, Portugal. ¹¹⁶NOVA University of Lisbon, Lisbon, Portugal. ¹¹⁷University of Pernambuco, Recife, Brazil. ¹¹⁸Baqai Institute of Diabetology and Endocrinology, Karachi, Pakistan. ¹¹⁹Federal University of Santa Catarina, Florianópolis, Brazil. ¹²⁰Dalhousie University, Halifax, Nova Scotia, Canada. ¹²¹Jordan University of Science and Technology, Irbid, Jordan. ¹²²Universidade Federal de Ouro Preto, Ouro Preto, Brazil. ¹²³Federal University of Maranhão, São Luís, Brazil. ¹²⁴University of Sydney, Sydney, New South Wales, Australia. ¹²⁵Cliniques Universitaires de Kinshasa, Kinshasa, Democratic Republic of the Congo. ¹²⁶University of Auckland, Auckland, New Zealand. ¹²⁷University College Dublin, Dublin, Ireland. ¹²⁸Christian Medical College, Vellore, India. ¹²⁹University Tunis El Manar, Tunis, Tunisia. ¹³⁰Federal Ministry of Social Affairs, Health, Care and Consumer Protection, Vienna, Austria. ¹³¹Cafam University Foundation, Bogotá, Colombia. ¹³²Ministerio de Salud Pública y Bienestar Social, Asunción, Paraguay. ¹³³University of Agder, Kristiansand, Norway. ¹³⁴Addis Continental Institute of Public Health, Addis Ababa, Ethiopia. ¹³⁵Kazakh National Medical University, Almaty, Kazakhstan. ¹³⁶Universidad Peruana Cayetano Heredia, Lima, Peru. ¹³⁷Lithuanian University of Health Sciences, Kaunas, Lithuania. ¹³⁸Pontificia Universidad Católica de Chile, Santiago, Chile. ¹³⁹University of São Paulo, São Paulo, Brazil. ¹⁴⁰Johannes Gutenberg University, Mainz, Germany. ¹⁴¹B. J. Medical College, Ahmedabad, India. ¹⁴²Chirayu Medical College, New Delhi, India. ¹⁴³Sunder Lal Jain Hospital, Delhi, India. ¹⁴⁴Shandong University of Traditional Chinese Medicine, Jinan, China. ¹⁴⁵Shanghai Jiao-Tong University School of Medicine, Shanghai, China. ¹⁴⁶Universidad de la República, Montevideo, Uruguay. ¹⁴⁷University of Strasbourg, Strasbourg, France. ¹⁴⁸Institute of Medical Research and Medicinal Plant Studies, Yaoundé, Cameroon. ¹⁴⁹Ufa Eye Research Institute, Ufa, Russia. ¹⁵⁰Nepal Health Research Council, Kathmandu, Nepal. ¹⁵¹University of Montenegro, Niksic, Montenegro. ¹⁵²University of Southern Denmark, Copenhagen, Denmark. ¹⁵³University of Gothenburg, Gothenburg, Sweden. ¹⁵⁴Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil. ¹⁵⁵National Institute for Public Health and the Environment, Bilthoven, The Netherlands. ¹⁵⁶University of Haifa, Haifa, Israel. ¹⁵⁷Ministry of Health, Ramat Gan, Israel. ¹⁵⁸University of Turin, Turin, Italy. ¹⁵⁹University College London, London, UK. ¹⁶⁰Liverpool John Moores University, Liverpool, UK. ¹⁶¹Nanyang Technological University, Singapore, Singapore. ¹⁶²National Medical Research Center for Endocrinology, Moscow, Russia. ¹⁶³Centro de Educación Médica e Investigaciones Clínicas, Buenos Aires, Argentina. ¹⁶⁴IRCCS Neuromed, Pozzilli, Italy. ¹⁶⁵Toulouse University School of Medicine, Toulouse, France. ¹⁶⁶University of Zurich, Zurich, Switzerland. ¹⁶⁷KU Leuven, Leuven, Belgium. ¹⁶⁸Ministry of Health, Victoria, Seychelles. ¹⁶⁹Unisanté, Lausanne, Switzerland. ¹⁷⁰World Health Organization Country Office in Tajikistan, Dushanbe, Tajikistan. ¹⁷¹Flemish Agency for Care and Health, Brussels, Belgium. ¹⁷²Ghent University, Ghent, Belgium. ¹⁷³FrieslandCampina, Amersfoort, The Netherlands. ¹⁷⁴Universidad Central de Venezuela, Caracas, Venezuela. ¹⁷⁵Bielefeld University, Bielefeld, Germany. ¹⁷⁶World Health Organization Athens Quality of Care Office, Athens, Greece. ¹⁷⁷German Cancer Research Center, Heidelberg, Germany. ¹⁷⁸The Fred Hollow Foundation, Auckland, New Zealand. ¹⁷⁹University of the Andes, Mérida, Venezuela. ¹⁸⁰Carol Davila University of Medicine and Pharmacy, Bucharest, Romania.

¹Imperial College London, London, UK. ²McGill University, Montreal, Québec, Canada.

³University of Essex, Colchester, UK. ⁴University of California Berkeley, Berkeley, CA, USA.

⁵University of Kent, Canterbury, UK. ⁶World Health Organization, Geneva, Switzerland.

⁷Harvard T. H. Chan School of Public Health, Boston, MA, USA. ⁸Mahidol University, Nakhon Pathom, Thailand. ⁹Ministry of Health, Kuala Lumpur, Malaysia. ¹⁰Bispebjerg and Frederiksberg Hospital, Copenhagen, Denmark. ¹¹Victor Babes University of Medicine and Pharmacy, Timisoara, Romania. ¹²Non-Communicable Diseases Research Center, Tehran, Iran. ¹³Swiss Tropical and Public Health Institute, Basel, Switzerland. ¹⁴University of Basel, Basel, Switzerland. ¹⁵World Health Organization Regional Office for Europe, Copenhagen, Denmark. ¹⁶National Institutes of Biomedical Innovation, Health and Nutrition, Tokyo, Japan. ¹⁷South African Medical Research Council, Cape Town, South Africa. ¹⁸Seoul National University College of Medicine, Seoul, Republic of Korea. ¹⁹University of Eastern Finland, Kuopio, Finland. ²⁰Finnish Institute for Health and Welfare, Helsinki, Finland. ²¹ICMR-National Institute of Nutrition, Hyderabad, India. ²²Peking University, Beijing, China. ²³Universidad de San Carlos, Guatemala City, Guatemala. ²⁴BRAC James P. Grant School of Public Health, Dhaka, Bangladesh. ²⁵University of Coimbra, Coimbra, Portugal. ²⁶University of Otago, Dunedin, New Zealand. ²⁷University of Zagreb, Zagreb, Croatia. ²⁸University of Ljubljana, Ljubljana, Slovenia. ²⁹GroundWork, Geneva, Switzerland. ³⁰Caja Costarricense de Seguro Social, San José, Costa Rica. ³¹Al-Quds University, East Jerusalem, State of Palestine. ³²National Center of Public Health, Astana, Kazakhstan. ³³Qatar University, Doha, Qatar. ³⁴Ministry of Health and Social Protection, Dushanbe, Tajikistan. ³⁵Birzeit University, Birzeit, State of Palestine. ³⁶Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria. ³⁷Instituto Mexicano del Seguro Social, Mexico City, Mexico. ³⁸Qassim University, Unaizah, Saudi Arabia. ³⁹RehaKlinika,

¹⁸¹Instituto Politécnico de Lisboa, Lisbon, Portugal. ¹⁸²Swansea University, Swansea, UK. ¹⁸³University College Copenhagen, Copenhagen, Denmark. ¹⁸⁴Institute of Public Health, Tirana, Albania. ¹⁸⁵Munster Technological University, Cork, Ireland. ¹⁸⁶Universidad de La Laguna, Santa Cruz de Tenerife, Spain. ¹⁸⁷University of Malta, Msida, Malta. ¹⁸⁸Vanderbilt University, Nashville, TN, USA. ¹⁸⁹Pan American Health Organization, Washington, DC, USA. ¹⁹⁰Ministry of Health, Tongatapu, Tonga. ¹⁹¹Canadian Fitness and Lifestyle Research Institute, Ottawa, Ontario, Canada. ¹⁹²Hospital Santa Maria, Lisbon, Portugal. ¹⁹³Istanbul University-Cerrahpasa, Istanbul, Turkey. ¹⁹⁴Universidade Federal de Juiz de Fora, Juiz de Fora, Brazil. ¹⁹⁵National Institute of Public Health, Prague, Czech Republic. ¹⁹⁶Gaetano Fucito Hospital, Mercato San Severino, Italy. ¹⁹⁷University of Groningen, Groningen, The Netherlands. ¹⁹⁸Karolinska Institutet, Huddinge, Sweden. ¹⁹⁹Centro de Estudios Sobre Nutrición Infantil, Buenos Aires, Argentina. ²⁰⁰University of Porto, Porto, Portugal. ²⁰¹University of Zaragoza, Zaragoza, Spain. ²⁰²Santiago de Compostela University, Santiago de Compostela, Spain. ²⁰³Ministry of Health, Ankara, Turkey. ²⁰⁴Council for Agricultural Research and Economics, Rome, Italy. ²⁰⁵Federal University of Rio Grande, Rio Grande, Brazil. ²⁰⁶India Diabetes Research Foundation, Chennai, India. ²⁰⁷Duke-NUS Medical School, Singapore, Singapore. ²⁰⁸ICMR-National Institute of Medical Statistics, New Delhi, India. ²⁰⁹Singapore Eye Research Institute, Singapore, Singapore. ²¹⁰Academia Sinica, Taipei, Taiwan. ²¹¹Capital Institute of Pediatrics, Beijing, China. ²¹²Xiangtan University, Xiangtan, China. ²¹³Kailuan General Hospital, Tangshan, China. ²¹⁴National University of Singapore, Singapore, Singapore. ²¹⁵US Centers for Disease Control and Prevention, Atlanta, GA, USA. ²¹⁶Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. ²¹⁷The Gertner Institute for Epidemiology and Health Policy Research, Ramat Gan, Israel. ²¹⁸National Centre of Public Health and Analyses, Sofia, Bulgaria. ²¹⁹Amsterdam UMC Public Health Research Institute, Amsterdam, The Netherlands. ²²⁰Universidad de Costa Rica, San José, Costa Rica. ²²¹University of Fribourg, Fribourg, Switzerland. ²²²National Taiwan University, Taipei, Taiwan. ²²³CIBERESP, Madrid, Spain. ²²⁴Seoul National University, Seoul, Republic of Korea. ²²⁵University of Southern Denmark, Odense, Denmark. ²²⁶Universidade Estadual Paulista, Presidente Prudente, Brazil. ²²⁷Medical University of Silesia, Katowice, Poland. ²²⁸Charles University, Prague, Czech Republic. ²²⁹Thomayer Hospital, Prague, Czech Republic. ²³⁰Primary Health Care, Floriana, Malta. ²³¹University of Salerno, Fisciano, Italy. ²³²Statistics Canada, Ottawa, Ontario, Canada. ²³³Alicante Institute for Health and Biomedical Research, Alicante, Spain. ²³⁴Agency for Preventive and Social Medicine, Bregenz, Austria. ²³⁵University of Southampton, Southampton, UK. ²³⁶Pontificia Universidad Javeriana, Bogotá, Colombia. ²³⁷Institut Pasteur de Lille, Lille, France. ²³⁸Malawi Epidemiology and Intervention Research Unit, Lilongwe, Malawi. ²³⁹CIBEROBN, Madrid, Spain. ²⁴⁰Hungarian University of Sports Science, Budapest, Hungary. ²⁴¹University of Debrecen, Debrecen, Hungary. ²⁴²National Institute of Public Health, Bucharest, Romania. ²⁴³University of Medicine and Pharmacy, Bucharest, Romania. ²⁴⁴Universidade Federal do Rio Grande do Norte, Natal, Brazil. ²⁴⁵National Research Council, Reggio Calabria, Italy. ²⁴⁶Eftimie Murgu University Resita, Resita, Romania. ²⁴⁷Eduardo Mondlane University, Maputo, Mozambique. ²⁴⁸Indian Statistical Institute, Kolkata, India. ²⁴⁹Tabriz Health Services Management Research Center, Tabriz, Iran. ²⁵⁰Geneva University Hospitals, Geneva, Switzerland. ²⁵¹Sciensano, Brussels, Belgium. ²⁵²University Medical Centers, Amsterdam, The Netherlands. ²⁵³National Research Centre for Preventive Medicine, Moscow, Russia. ²⁵⁴Innovating Health International, Port-au-Prince, Haiti. ²⁵⁵University of Montreal, Montreal, Quebec, Canada. ²⁵⁶French National Research Institute for Sustainable Development, Montpellier, France. ²⁵⁷French Public Health Agency, St Maurice, France. ²⁵⁸Mediterranea Cardiocentro, Naples, Italy. ²⁵⁹Universidade do Vale do Rio dos Sinos, São Leopoldo, Brazil. ²⁶⁰National Institute of Hygiene, Epidemiology and Microbiology, Havana, Cuba. ²⁶¹National Council of Scientific and Technical Research, Buenos Aires, Argentina. ²⁶²Servicio Canario de la Salud del Gobierno de Canarias, Santa Cruz de Tenerife, Spain. ²⁶³Consejería de Salud del Gobierno de La Rioja, Logroño, Spain. ²⁶⁴Ministry of Health and Medical Education, Tehran, Iran. ²⁶⁵University of Novi Sad, Novi Sad, Serbia. ²⁶⁶National Institute of Nutrition, Hanoi, Vietnam. ²⁶⁷University of Queensland, Brisbane, Queensland, Australia. ²⁶⁸Instituto de Investigación Nutricional, Lima, Peru. ²⁶⁹Istituto Superiore di Sanità, Rome, Italy. ²⁷⁰Sun Yat-sen University, Guangzhou, China. ²⁷¹Universidad de Cuenca, Cuenca, Ecuador. ²⁷²Helmholtz Zentrum München, Munich, Germany. ²⁷³Tehran University of Medical Sciences, Tehran, Iran. ²⁷⁴Ministère de la Santé et de l'Hygiène Publique, Abidjan, Côte d'Ivoire. ²⁷⁵University Hospital Düsseldorf, Düsseldorf, Germany. ²⁷⁶National Institute of Cardiology, Warsaw, Poland. ²⁷⁷Beijing Center for Disease Prevention and Control, Beijing, China. ²⁷⁸IRL 3189 ESS, Marseille, France. ²⁷⁹Scuola Superiore Sant'Anna, Pisa, Italy. ²⁸⁰Al-Farabi Kazakh National University, Almaty, Kazakhstan. ²⁸¹Semey Medical University, Semey, Kazakhstan. ²⁸²University of Latvia, Riga, Latvia. ²⁸³Ministry of Health and Medical Services, Gizo, Solomon Islands. ²⁸⁴Hormozgan University of Medical Sciences, Bandar Abbas, Iran. ²⁸⁵University of Benin, Benin City, Nigeria. ²⁸⁶University of Skövde, Skövde, Sweden. ²⁸⁷Ministry of Health, Rabat, Morocco. ²⁸⁸National Institute of Nutrition and Food Technology, Tunis, Tunisia. ²⁸⁹The University of the West Indies, Kingston, Jamaica. ²⁹⁰Ministry of Health, Jerusalem, Israel. ²⁹¹University of California Davis, Davis, CA, USA. ²⁹²University of Stellenbosch, Cape Town, South Africa. ²⁹³University of Duisburg-Essen, Essen, Germany. ²⁹⁴Karadeniz Technical University, Trabzon, Turkey. ²⁹⁵Dokuz Eylül University, Izmir, Turkey. ²⁹⁶University of Helsinki, Helsinki, Finland. ²⁹⁷Mashhad University of Medical Sciences, Mashhad, Iran. ²⁹⁸Rafsanjan University of Medical Sciences, Rafsanjan, Iran. ²⁹⁹Queen's University Belfast, Belfast, UK. ³⁰⁰Tabriz University of Medical Sciences, Tabriz, Iran. ³⁰¹Fasa University of Medical Sciences, Fasa, Iran. ³⁰²Shiraz University of Medical Sciences, Shiraz, Iran. ³⁰³Baqai Medical University, Karachi, Pakistan. ³⁰⁴Centro de Salud Villanueva Norte, Badajoz, Spain. ³⁰⁵Hospital Don Benito-Villanueva de la Serena, Badajoz, Spain. ³⁰⁶Ministry of Health, Buenos Aires, Argentina. ³⁰⁷Universidad de Santiago de Chile, Santiago, Chile. ³⁰⁸University of Insubria, Varese, Italy. ³⁰⁹Federal University of Alagoas, Alagoas, Brazil. ³¹⁰Institute of Mother and Child, Warsaw, Poland. ³¹¹Hospital Infantil Sabará, São Paulo, Brazil. ³¹²University of Tartu, Tartu, Estonia. ³¹³Universiti Sains Malaysia, Kelantan, Malaysia. ³¹⁴Umeå University, Umeå, Sweden. ³¹⁵Federal University of São Paulo, São Paulo, Brazil. ³¹⁶University Clinical Centre Ljubljana, Ljubljana, Slovenia. ³¹⁷Hospital Universitario Son Espases, Palma, Spain. ³¹⁸Hospital de Clinicas de Porto Alegre, Porto Alegre, Brazil. ³¹⁹Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil. ³²⁰Universitas Sumatara Utara, Medan, Indonesia. ³²¹Kindai University, Osaka-Sayama, Japan. ³²²Kyoto University, Kyoto, Japan. ³²³Horbachevsky Ternopil National Medical University, Ternopil, Ukraine. ³²⁴Medical University of Warsaw, Warsaw, Poland. ³²⁵Consejería de Sanidad del Gobierno de Cantabria, Santander, Spain. ³²⁶Jagiellonian University Medical College, Kraków, Poland. ³²⁷Ministero della Salute DG Prevenzione Sanitaria, Rome, Italy. ³²⁸University of Catania, Catania, Italy. ³²⁹Agencia Española de Seguridad Alimentaria y Nutrición, Madrid, Spain. ³³⁰Africa Health Research Institute, Mtubatuba, South Africa. ³³¹Geneva University Medical School, Geneva, Switzerland. ³³²Universidade Federal de Minas Gerais, Belo Horizonte, Brazil. ³³³Utrecht University, Utrecht, The Netherlands. ³³⁴Wageningen University, Wageningen, The Netherlands. ³³⁵Medical Research Foundation, Chennai, India. ³³⁶Kurdistan University of Medical Sciences, Sanandaj, Iran. ³³⁷University of Adelaide, Adelaide, South Australia, Australia. ³³⁸Lund University, Lund, Sweden. ³³⁹Aristotle University of Thessaloniki, Thessaloniki, Greece. ³⁴⁰National Institute for Health Development, Tallinn, Estonia. ³⁴¹Central University of Kerala, Kasargod, India. ³⁴²Institut National de la Santé et de la Recherche Médicale, Paris, France. ³⁴³Paris University, Paris, France. ³⁴⁴Instituto Murciano de Investigación Biosanitaria Virgen de la Arrixaca, Murcia, Spain. ³⁴⁵Casol Foundation, Sant Boi de Llobregat, Spain. ³⁴⁶University of Lleida, Sant Boi de Llobregat, Spain. ³⁴⁷PASs Hirsfeld Institute of Immunology and Experimental Therapy, Wrocław, Poland. ³⁴⁸University Agostinho Neto, Luanda, Angola. ³⁴⁹Kansas State University, Manhattan, KS, USA. ³⁵⁰Universidad Politécnica de Madrid, Madrid, Spain. ³⁵¹International Clinical Research Center, Brno, Czech Republic. ³⁵²National Institute of Public Health, Cuernavaca, Mexico. ³⁵³Centro de Estudios en Diabetes A.C., Mexico City, Mexico. ³⁵⁴Universidad Autónoma de Santo Domingo, Santo Domingo, Dominican Republic. ³⁵⁵Ministry of Health, Lisbon, Portugal. ³⁵⁶Institute for Clinical and Experimental Medicine, Prague, Czech Republic. ³⁵⁷Children's Memorial Health Institute, Warsaw, Poland. ³⁵⁸University of Thessaly, Larissa, Greece. ³⁵⁹National Center of Cardiovascular Diseases, Beijing, China. ³⁶⁰International Life Science Institute, Buenos Aires, Argentina. ³⁶¹University of Ferrara, Ferrara, Italy. ³⁶²Authority Sanitaria San Marino, San Marino, San Marino. ³⁶³Icelandic Heart Association, Kopavogur, Iceland. ³⁶⁴Universidad Icesi, Cali, Colombia. ³⁶⁵State University of Montes Claros, Montes Claros, Brazil. ³⁶⁶King's College London, London, UK. ³⁶⁷International Agency for Research on Cancer, Lyon, France. ³⁶⁸Capital Medical University, Beijing, China. ³⁶⁹Capital Medical University Beijing Tongren Hospital, Beijing, China. ³⁷⁰Healis-Seksharia Institute for Public Health, Navi Mumbai, India. ³⁷¹Eternal Heart Care Centre and Research Institute, Jaipur, India. ³⁷²University of Ibadan, Ibadan, Nigeria. ³⁷³Institute for Clinical Effectiveness and Health Policy, Buenos Aires, Argentina. ³⁷⁴National Health Insurance Service, Wonju, Republic of Korea. ³⁷⁵Prevention of Metabolic Disorders Research Center, Tehran, Iran. ³⁷⁶Research and Education Institute of Child Health, Nicosia, Cyprus. ³⁷⁷Danish Cancer Society Research Center, Copenhagen, Denmark. ³⁷⁸The University of the West Indies, Cave Hill, Barbados. ³⁷⁹Kermanshah University of Medical Sciences, Kermanshah, Iran. ³⁸⁰Africa Health Research Institute, Durban, South Africa. ³⁸¹Federal University of Pernambuco, Recife, Brazil. ³⁸²Yasuj University of Medical Sciences, Yasuj, Iran. ³⁸³International Hellenic University, Thessaloniki, Greece. ³⁸⁴Kyushu University, Fukuoka, Japan. ³⁸⁵University of Bergen, Bergen, Norway. ³⁸⁶Tulane University, New Orleans, LA, USA. ³⁸⁷National Research Institute for Health and Family Planning, Beijing, China. ³⁸⁸Chinese Center for Disease Control and Prevention, Beijing, China. ³⁸⁹University of Pécs, Pécs, Hungary. ³⁹⁰Danish Health Authority, Copenhagen, Denmark. ³⁹¹Joep Lange Institute, Amsterdam, The Netherlands. ³⁹²Universidad Autónoma de Bucaramanga, Bucaramanga, Colombia. ³⁹³ETH Zurich, Zurich, Switzerland. ³⁹⁴Chronic Diseases Research Center, Tehran, Iran. ³⁹⁵University of Hong Kong, Hong Kong, China. ³⁹⁶The Chinese University of Hong Kong, Hong Kong, China. ³⁹⁷University of Western Australia, Perth, Western Australia, Australia. ³⁹⁸Universidade Federal do Paraná, Curitiba, Brazil. ³⁹⁹Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁴⁰⁰Casol Foundation, Barcelona, Spain. ⁴⁰¹University Ramon Llull, Sant Boi de Llobregat, Spain. ⁴⁰²Kingston Health Sciences Centre, Kingston, Ontario, Canada. ⁴⁰³Fundación Oftalmológica de Santander, Bucaramanga, Colombia. ⁴⁰⁴University Oran 1, Oran, Algeria. ⁴⁰⁵Independent Public Health Specialist, Nay Pyi Taw, Myanmar. ⁴⁰⁶Ministry of Health and Sports, Nay Pyi Taw, Myanmar. ⁴⁰⁷Santé publique France, Saint-Maurice, France. ⁴⁰⁸VU University Medical Center, Amsterdam, The Netherlands. ⁴⁰⁹American University of Beirut, Beirut, Lebanon. ⁴¹⁰Cairo University, Cairo, Egypt. ⁴¹¹Erasmus Medical Center Rotterdam, Rotterdam, The Netherlands. ⁴¹²University of Valencia, Valencia, Spain. ⁴¹³Medical University Varna, Varna, Bulgaria. ⁴¹⁴The University of Tokyo, Tokyo, Japan. ⁴¹⁵Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Nigeria. ⁴¹⁶The Hospital for Sick Children, Toronto, Ontario, Canada. ⁴¹⁷Deakin University, Geelong, Victoria, Australia. ⁴¹⁸Emory University, Atlanta, GA, USA. ⁴¹⁹Bulgarian Academy of Sciences, Sofia, Bulgaria. ⁴²⁰Tokyo Metropolitan Institute of Gerontology, Tokyo, Japan. ⁴²¹Hadassah University Medical Center, Jerusalem, Israel. ⁴²²Université Catholique de Louvain, Brussels, Belgium. ⁴²³Gambia National Nutrition Agency, Banjul, The Gambia. ⁴²⁴Kuwait Institute for Scientific Research, Safat, Kuwait. ⁴²⁵Public Health Agency of Sweden, Solna, Sweden. ⁴²⁶Norwegian University of Science and Technology, Trondheim, Norway. ⁴²⁷University of Melbourne, Melbourne, Victoria, Australia. ⁴²⁸Sports University of Tirana, Tirana, Albania. ⁴²⁹Heart Foundation, Melbourne, Victoria, Australia. ⁴³⁰Guangzhou 12th Hospital, Guangzhou, China. ⁴³¹Universidad Eugenio María de Hostos, Santo Domingo, Dominican Republic. ⁴³²Simon Fraser University, Burnaby, British Columbia, Canada. ⁴³³Institute of Molecular and Clinical Ophthalmology Basel, Basel, Switzerland. ⁴³⁴University of New South Wales, Sydney, New South Wales, Australia. ⁴³⁵World Health Organization Country Office, Delhi, India. ⁴³⁶Guilan University of Medical Sciences, Rasht, Iran. ⁴³⁷University of Opole, Opole, Poland. ⁴³⁸Gulu University, Gulu, Uganda. ⁴³⁹University of Crete, Heraklion, Greece. ⁴⁴⁰Hungarian School Sport Federation, Budapest, Hungary. ⁴⁴¹National Center for Disease Control and Public Health, Tbilisi, Georgia. ⁴⁴²Ministry of Health, Bratislava, Slovakia. ⁴⁴³Sri Venkateswara University, Tirupati, India. ⁴⁴⁴Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, India. ⁴⁴⁵Hellenic Medical Association for Obesity, Athens, Greece. ⁴⁴⁶Harokopio University, Athens, Greece. ⁴⁴⁷National and Kapodistrian University of Athens, Athens, Greece. ⁴⁴⁸Maharajgunj Medical Campus, Kathmandu, Nepal. ⁴⁴⁹Université Officielle de Bukavu, Bukavu, Democratic Republic of the Congo. ⁴⁵⁰Aarhus University, Aarhus, Denmark. ⁴⁵¹Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA. ⁴⁵²Pennington Biomedical Research Center, Baton Rouge, LA, USA. ⁴⁵³National Institute of Epidemiology, Chennai, India. ⁴⁵⁴University of Toronto, Toronto, Ontario, Canada. ⁴⁵⁵University of Münster, Münster, Germany. ⁴⁵⁶Israel Center for Disease Control, Ramat Gan, Israel. ⁴⁵⁷Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan, Iran. ⁴⁵⁸Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan. ⁴⁵⁹Research Institute of Child Nutrition, Dortmund, Germany. ⁴⁶⁰Shahrekor University of Medical Sciences, Shahrekord, Iran. ⁴⁶¹University of Cambridge, Cambridge, UK. ⁴⁶²Mazandaran University of Medical Sciences, Sari, Iran. ⁴⁶³Hypertension Research Center, Isfahan, Iran. ⁴⁶⁴Medical University of Innsbruck, Innsbruck, Austria. ⁴⁶⁵VASCage, Innsbruck, Austria. ⁴⁶⁶Muhimbili University of

Article

Health and Allied Sciences, Dar es Salaam, Tanzania. ⁴⁶⁷Yonsei University College of Medicine, Seoul, Republic of Korea. ⁴⁶⁸National Cancer Center, Goyang-si, Republic of Korea. ⁴⁶⁹Sahlgrenska University Hospital, Gothenburg, Sweden. ⁴⁷⁰Newcastle University, Newcastle, UK. ⁴⁷¹University College South Denmark, Haderslev, Denmark. ⁴⁷²Statistics Austria, Vienna, Austria. ⁴⁷³B. P. Koirala Institute of Health Sciences, Dharan, Nepal. ⁴⁷⁴University of Vienna, Vienna, Austria. ⁴⁷⁵Tartu University Clinics, Tartu, Estonia. ⁴⁷⁶Kansai Medical University, Hirakata, Japan. ⁴⁷⁷District Department of State Public Health Service, Hildburghausen, Germany. ⁴⁷⁸Pontificia Universidad Católica Argentina, Buenos Aires, Argentina. ⁴⁷⁹Ministry of Health and Wellness, Port Louis, Mauritius. ⁴⁸⁰University Hospital Ulm, Ulm, Germany. ⁴⁸¹Croatian Institute of Public Health, Zagreb, Croatia. ⁴⁸²Institute of Nutrition of Central America and Panama, Guatemala City, Guatemala. ⁴⁸³North-West University, Potchefstroom, South Africa. ⁴⁸⁴South African Medical Research Council, Potchefstroom, South Africa. ⁴⁸⁵University of Physical Education, Kraków, Poland. ⁴⁸⁶University of Jyväskylä, Jyväskylä, Finland. ⁴⁸⁷Institute of Public Health, Podgorica, Montenegro. ⁴⁸⁸Amrita Institute of Medical Sciences, Cochin, India. ⁴⁸⁹Institute of Endocrinology, Prague, Czech Republic. ⁴⁹⁰All India Institute of Medical Sciences, New Delhi, India. ⁴⁹¹African Population and Health Research Center, Nairobi, Kenya. ⁴⁹²Hanoi University of Public Health, Hanoi, Vietnam. ⁴⁹³Hassan First University of Settat, Settat, Morocco. ⁴⁹⁴Ministry of Health, Algiers, Algeria. ⁴⁹⁵Ministry of Health, Georgetown, Guyana. ⁴⁹⁶Sahlgrenska Academy, Gothenburg, Sweden. ⁴⁹⁷Endocrinology and Metabolism Research Center, Tehran, Iran. ⁴⁹⁸Clinical Research Education, Networking & Consultancy, Douala, Cameroon. ⁴⁹⁹University of Public Health, Yangon, Myanmar. ⁵⁰⁰Centro Studi Epidemiologici di Gubbio, Gubbio, Italy. ⁵⁰¹National University Health System, Singapore, Singapore. ⁵⁰²University of Leicester, Leicester, UK. ⁵⁰³Tampere University Hospital, Tampere, Finland. ⁵⁰⁴Tampere University, Tampere, Finland. ⁵⁰⁵University of Douala, Douala, Cameroon. ⁵⁰⁶University of Cape Town, Cape Town, South Africa. ⁵⁰⁷West Virginia University, Morgantown, WV, USA. ⁵⁰⁸Oswaldo Cruz Foundation Rene Rachou Research Institute, Belo Horizonte, Brazil. ⁵⁰⁹Shanghai Institute of Nutrition and Health of Chinese Academy of Sciences, Shanghai, China. ⁵¹⁰Uppsala University, Uppsala, Sweden. ⁵¹¹Capital Medical University Beijing An Zhen Hospital, Beijing, China. ⁵¹²Taipei Medical University, Taipei, Taiwan. ⁵¹³Servicio Andaluz de Salud, Sevilla, Spain. ⁵¹⁴Sports Medical Center of Minho, Braga, Portugal. ⁵¹⁵Universidad San Martín de Porres, Lima, Peru. ⁵¹⁶Consejería de Sanidad Junta de Castilla y León, Valladolid, Spain. ⁵¹⁷Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, Brazil. ⁵¹⁸Imbula Lutheran Hospital, Imbula, Tanzania. ⁵¹⁹University of Kinshasa Hospital, Kinshasa, Democratic Republic of the Congo. ⁵²⁰Coimbra University Hospital Center, Coimbra, Portugal. ⁵²¹University of Texas Rio Grande Valley, Harlingen, TX, USA. ⁵²²Institute of Neuroscience of the National Research Council, Padua, Italy. ⁵²³Baker Heart and Diabetes Institute, Melbourne, Victoria, Australia. ⁵²⁴Agricultural University of Athens, Athens, Greece. ⁵²⁵Academia VBHC, São Paulo, Brazil. ⁵²⁶GB RAS Federal Research Center Institute of Cytology and Genetics, Novosibirsk, Russia. ⁵²⁷Université Catholique de Bukavu, Bukavu, Democratic Republic of the Congo. ⁵²⁸University of Northern British Columbia, Prince George, British Columbia, Canada. ⁵²⁹University of Padua, Padua, Italy. ⁵³⁰University Medicine Greifswald, Greifswald, Germany. ⁵³¹Hellenic Mediterranean University, Siteia, Greece. ⁵³²Loughborough University, Loughborough, UK. ⁵³³Ministry of Health, Nicosia, Cyprus. ⁵³⁴Lausanne University Hospital, Lausanne, Switzerland. ⁵³⁵University of Lausanne, Lausanne, Switzerland. ⁵³⁶Secretaría de Estado da Saúde de Santa Catarina, Florianópolis, Brazil. ⁵³⁷CIBERCV, Barcelona, Spain. ⁵³⁸Institut Hospital del Mar d'Investigacions Mèdiques, Barcelona, Spain. ⁵³⁹Mary Immaculate College, Limerick, Ireland. ⁵⁴⁰Hungarian Society of Sports Medicine, Budapest, Hungary. ⁵⁴¹Paracelsus Medical University, Salzburg, Austria. ⁵⁴²Institute for Cancer Research, Prevention and Clinical Network, Florence, Italy. ⁵⁴³Universidade Estadual do Centro-Oeste, Guarapuava, Brazil. ⁵⁴⁴Sher-i-Kashmir Institute of Medical Sciences, Srinagar, India. ⁵⁴⁵UIT The Arctic University of Norway, Tromsø, Norway. ⁵⁴⁶ICMR–National Centre for Disease Informatics and Research, Bengaluru, India. ⁵⁴⁷Sefako Makgatho Health Sciences University, Pretoria, South Africa. ⁵⁴⁸Centro de Estudos do Laboratório de Aptidão Física de São Caetano do Sul, São Paulo, Brazil. ⁵⁴⁹Brown University, Providence, RI, USA. ⁵⁵⁰London School of Hygiene & Tropical Medicine, London, UK. ⁵⁵¹University of Edinburgh, Edinburgh, UK. ⁵⁵²Weill Cornell Medicine, New York City, NY, USA. ⁵⁵³Institut National de la Santé et de la Recherche Médicale, Lille, France. ⁵⁵⁴Arakir Medical Centre–Institute of Child and Adolescent Health, Yerevan, Armenia. ⁵⁵⁵Universidad de los Andes, Bogotá, Colombia. ⁵⁵⁶Robert Koch Institute, Berlin, Germany. ⁵⁵⁷University of Abidjan, Abidjan, Côte d'Ivoire. ⁵⁵⁸Pirogov Russian National Research Medical University, Moscow, Russia. ⁵⁵⁹Universidade de Lisboa, Lisbon, Portugal. ⁵⁶⁰Saveetha Dental Colleges & Hospitals, Chennai, India. ⁵⁶¹Democritus University, Alexandroupolis, Greece. ⁵⁶²Grigore T Popa University of Medicine and Pharmacy, Iasi, Romania. ⁵⁶³Università degli Studi di Firenze, Florence, Italy. ⁵⁶⁴Ain Shams University, Cairo, Egypt. ⁵⁶⁵Isfahan Cardiovascular Research Center, Isfahan, Iran. ⁵⁶⁶Strasbourg University Hospital, Strasbourg, France. ⁵⁶⁷Mulago Hospital, Kampala, Uganda. ⁵⁶⁸Instituto Conmemorativo Gorgas de Estudios de la Salud, Panama City, Panama. ⁵⁶⁹University of Limpopo, Sovenga, South Africa. ⁵⁷⁰University of Medical Sciences of Cienfuegos, Cienfuegos, Cuba. ⁵⁷¹Ministry of Health and Wellness, Belmopan, Belize. ⁵⁷²Royal College of Surgeons in Ireland, Dublin, Ireland. ⁵⁷³La Trobe University, Melbourne, Victoria, Australia. ⁵⁷⁴Sabzevar University of Medical Sciences, Sabzevar, Iran. ⁵⁷⁵International Institute of Molecular and Cell Biology, Warsaw, Poland. ⁵⁷⁶World Health Organization Country Office, Lilongwe, Malawi. ⁵⁷⁷Department of Public Health, Nay Pyi Taw, Myanmar. ⁵⁷⁸Albanian Sports Science Association, Tirana, Albania. ⁵⁷⁹University of Brescia, Brescia, Italy. ⁵⁸⁰University of Limerick, Limerick, Ireland. ⁵⁸¹Makerere University School of Public Health, Kampala, Uganda. ⁵⁸²University de Kinshasa, Kinshasa, Democratic Republic of the Congo. ⁵⁸³Bushehr University of Medical Sciences, Bushehr, Iran. ⁵⁸⁴Ulm University, Ulm, Germany. ⁵⁸⁵Suraj Eye Institute, Nagpur, India. ⁵⁸⁶UNICEF, Yaounde, Cameroon. ⁵⁸⁷Ministry of Health, Apia, Samoa. ⁵⁸⁸Karolinska Institutet, Stockholm, Sweden. ⁵⁸⁹National Institute of Hygiene and Epidemiology, Hanoi, Vietnam. ⁵⁹⁰University of Medicine and Pharmacy, Ho Chi Minh City, Vietnam. ⁵⁹¹Hanoi Medical University, Hanoi, Vietnam. ⁵⁹²Xi'an Jiaotong University, Xi'an, China. ⁵⁹³LifeDoc Health, Memphis, TN, USA. ⁵⁹⁴Hearthfile, Islamabad, Pakistan. ⁵⁹⁵Eastern Mediterranean Public Health Network, Amman, Jordan. ⁵⁹⁶University of Manchester, Manchester, UK. ⁵⁹⁷State University of Medicine and Pharmacy, Chisinau, Moldova. ⁵⁹⁸Tachikawa General Hospital, Nagaoka, Japan. ⁵⁹⁹University of Abuja College of Health Sciences, Abuja, Nigeria. ⁶⁰⁰Korea Centers for Disease Control and Prevention, Cheongju-si, Republic of Korea. ⁶⁰¹Japan Wildlife Research Center, Tokyo, Japan. ⁶⁰²Gadarif University, Gadarif, Sudan. ⁶⁰³Istanbul University, Istanbul, Turkey. ⁶⁰⁴Ministry of Health, Bandar Seri Begawan, Brunei. ⁶⁰⁵University of Madeira, Funchal, Portugal. ⁶⁰⁶University of Puerto Rico, San Juan, Puerto Rico. ⁶⁰⁷Osteoporosis Research Center, Tehran, Iran. ⁶⁰⁸Universidad de Santander, Bucaramanga, Colombia. ⁶⁰⁹Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. ⁶¹⁰University of Wisconsin-Madison, Madison, WI, USA. ⁶¹¹Privatpraxis Prof Jonas und Dr Panda-Jonas, Heidelberg, Germany. ⁶¹²IRCCS Ente Ospedaliero Specializzato in Gastroenterologia S. de Bellis, Bari, Italy. ⁶¹³Zayed University, Abu Dhabi, United Arab Emirates. ⁶¹⁴Catholic University of Daegu, Daegu, Republic of Korea. ⁶¹⁵University of Medicine, Pharmacy, Science and Technology of Târgu Mures, Târgu Mures, Romania. ⁶¹⁶Jivandeep Hospital, Anand, India. ⁶¹⁷Centro de Investigação em Saúde de Angola, Caxito, Angola. ⁶¹⁸South African Medical Research Council, Durban, South Africa. ⁶¹⁹National Dental Care Centre Singapore, Singapore, Singapore. ⁶²⁰University Hospital of Varese, Varese, Italy. ⁶²¹Vietnam National Heart Institute, Hanoi, Vietnam. ⁶²²Clinica de Medicina Avanzada Dr. Abel González, Santo Domingo, Dominican Republic. ⁶²³University of Sarajevo, Sarajevo, Bosnia and Herzegovina. ⁶²⁴Cardiovascular Prevention Centre Udine, Udine, Italy. ⁶²⁵University of Pisa, Pisa, Italy. ⁶²⁶Ministry of Health and Medical Services, Honiara, Solomon Islands. ⁶²⁷Public Health Agency of Catalonia, Barcelona, Spain. ⁶²⁸O. M. Marzeyev Institute for Public Health of the National Academy of the Medical Sciences of Ukraine, Kyiv, Ukraine. ⁶²⁹Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia. ⁶³⁰Ardabil University of Medical Sciences, Ardabil, Iran. ⁶³¹Universidade Pedagógica, Maputo, Mozambique. ⁶³²Centre for Disease Prevention and Control, Riga, Latvia. ⁶³³Sulaimani Polytechnic University, Sulaymaniyah, Iraq. ⁶³⁴Alborz University of Medical Sciences, Karaj, Iran. ⁶³⁵Ministry of Health, Hanoi, Vietnam. ⁶³⁶Pure Earth, Dhaka, Bangladesh. ⁶³⁷Institute of Epidemiology Disease Control and Research, Dhaka, Bangladesh. ⁶³⁸University of Turku, Turku, Finland. ⁶³⁹UNICEF, Baku, Azerbaijan. ⁶⁴⁰World Health Organization Country Office, Juba, South Sudan. ⁶⁴¹Instituto Federal Riograndense, Rio Grande, Brazil. ⁶⁴²Institut Universitari d'Investigació en Atenció Primària Jordi Gol, Girona, Spain. ⁶⁴³Universiti Putra Malaysia, Serdang, Malaysia. ⁶⁴⁴University of Malaya, Kuala Lumpur, Malaysia. ⁶⁴⁵Sotiria Hospital, Athens, Greece. ⁶⁴⁶University of the Philippines, Manila, The Philippines. ⁶⁴⁷Slovak Academy of Sciences, Bratislava, Slovakia. ⁶⁴⁸University of Santa Cruz do Sul, Santa Cruz do Sul, Brazil. ⁶⁴⁹Nutrition Research Foundation, Barcelona, Spain. ⁶⁵⁰Minas Gerais State Secretariat for Health, Belo Horizonte, Brazil. ⁶⁵¹CS S. Agustín Ibsalut, Palma, Spain. ⁶⁵²Amsterdam Institute for Global Health and Development, Amsterdam, The Netherlands. ⁶⁵³Universidade Nove de Julho, São Paulo, Brazil. ⁶⁵⁴Ministerio de Salud, Panama City, Panama. ⁶⁵⁵Public Health Agency of Canada, Ottawa, Ontario, Canada. ⁶⁵⁶Universidad Industrial de Santander, Bucaramanga, Colombia. ⁶⁵⁷Ministry of Health and Social Protection, Bogotá, Colombia. ⁶⁵⁸Wuqu' Kawoq, Tecpan, Guatemala. ⁶⁵⁹GroundWork, Fläsch, Switzerland. ⁶⁶⁰Associazione Calabrese di Epatologia, Reggio Calabria, Italy. ⁶⁶¹University of Minho, Braga, Portugal. ⁶⁶²Fiji National University, Suva, Fiji. ⁶⁶³GHESKIO Clinics, Port-au-Prince, Haiti. ⁶⁶⁴Universidad de San Carlos, Quetzaltenango, Guatemala. ⁶⁶⁵National Center for Epidemiology CIBERESP, Madrid, Spain. ⁶⁶⁶Institute of Food Sciences of the National Research Council, Avellino, Italy. ⁶⁶⁷Medical University of Gdansk, Gdansk, Poland. ⁶⁶⁸Sitarum Bhartia Institute of Science and Research, New Delhi, India. ⁶⁶⁹Kindergarten of Avlonari, Evia, Greece. ⁶⁷⁰National Institute of Health, Lima, Peru. ⁶⁷¹Ministry of Health, Jakarta, Indonesia. ⁶⁷²Catalan Department of Health, Barcelona, Spain. ⁶⁷³Biodonostia Health Research Institute, San Sebastián, Spain. ⁶⁷⁴Instituto de Saúde Ambiental, Lisbon, Portugal. ⁶⁷⁵Federal University of Alagoas, Maceió, Brazil. ⁶⁷⁶South Karelia Social and Health Care District, Lappeenranta, Finland. ⁶⁷⁷National Cancer Center, Tokyo, Japan. ⁶⁷⁸University of São Paulo Clinics Hospital, São Paulo, Brazil. ⁶⁷⁹Hospital Italiano de Buenos Aires, Buenos Aires, Argentina. ⁶⁸⁰Medical University of Vienna, Vienna, Austria. ⁶⁸¹Rigshospitalet, Copenhagen, Denmark. ⁶⁸²Academic Medical Center of University of Amsterdam, Amsterdam, The Netherlands. ⁶⁸³German Institute of Human Nutrition Potsdam-Rehbruecke, Nuthetal, Germany. ⁶⁸⁴The George Institute for Global Health, Sydney, New South Wales, Australia. ⁶⁸⁵Center for Oral Health Services and Research Mid-Norway, Trondheim, Norway. ⁶⁸⁶Lagos State University College of Medicine, Lagos, Nigeria. ⁶⁸⁷University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain. ⁶⁸⁸Comenius University, Bratislava, Slovakia. ⁶⁸⁹Teikyo University, Tokyo, Japan. ⁶⁹⁰Finnish Institute of Occupational Health, Helsinki, Finland. ⁶⁹¹Rutgers University, New Brunswick, NJ, USA. ⁶⁹²National Agency for Public Health, Chisinau, Moldova. ⁶⁹³St Vincent's Hospital, Sydney, New South Wales, Australia. ⁶⁹⁴Nes Municipality, Årnes, Norway. ⁶⁹⁵Health Polytechnic Jakarta II Institute, Jakarta, Indonesia. ⁶⁹⁶Diponegoro University, Semarang, Indonesia. ⁶⁹⁷University of Bari, Bari, Italy. ⁶⁹⁸Institut Régional de Santé Publique, Ouidah, Benin. ⁶⁹⁹University of Bordeaux, Bordeaux, France. ⁷⁰⁰University of Hohenheim, Stuttgart, Germany. ⁷⁰¹Oslo Metropolitan University, Oslo, Norway. ⁷⁰²Institute of Public Health, Skopje, North Macedonia. ⁷⁰³Ss. Cyril and Methodius University, Skopje, North Macedonia. ⁷⁰⁴Lamprecht und Stamm Sozialforschung und Beratung AG, Zurich, Switzerland. ⁷⁰⁵Bonn University, Bonn, Germany. ⁷⁰⁶National Institute of Public Health–National Institute of Hygiene, Warsaw, Poland. ⁷⁰⁷Kalina Malina Kindergarten, Pazardjik, Bulgaria. ⁷⁰⁸The Jikei University School of Medicine, Tokyo, Japan. ⁷⁰⁹Fu Jen Catholic University, Taipei, Taiwan. ⁷¹⁰University of Jordan, Amman, Jordan. ⁷¹¹National Statistical Office, Praia, Cabo Verde. ⁷¹²Monash University, Melbourne, Victoria, Australia. ⁷¹³Scientific Research Institute of Maternal and Child Health, Ashgabat, Turkmenistan. ⁷¹⁴University of Lincoln, Lincoln, UK. ⁷¹⁵Ministry of Health, Amman, Jordan. ⁷¹⁶UNICEF, Niamey, Niger. ⁷¹⁷University of Applied Sciences Utrecht, Utrecht, The Netherlands. ⁷¹⁸University Medical Center Utrecht, Utrecht, The Netherlands. ⁷¹⁹National Research and Innovation Agency, Jakarta, Indonesia. ⁷²⁰Health Service, Murcia, Spain. ⁷²¹Institut d'Investigació Sanitària Illes Balears, Menorca, Spain. ⁷²²University of Bologna, Bologna, Italy. ⁷²³Children's Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada. ⁷²⁴Hellenic Health Foundation, Athens, Greece. ⁷²⁵Government Medical College, Bhavnagar, India. ⁷²⁶Institute of Epidemiology and Preventive Medicine, Taipei, Taiwan. ⁷²⁷Sefako Makgatho Health Sciences University, Ga-Rankuwa, South Africa. ⁷²⁸Department of Health, Faga'a'u, American Samoa. ⁷²⁹LBJ Hospital, Faga'a'u, American Samoa. ⁷³⁰Addis Ababa University, Addis Ababa, Ethiopia. ⁷³¹Ministry of Health, Wellington, New Zealand. ⁷³²Israel Defense Forces Medical Corps, Tel Hashomer, Israel. ⁷³³Universidad Centro–Occidental Lisandro Alvarado, Barquisimeto, Venezuela. ⁷³⁴Meharry Medical College, Nashville, TN, USA. ⁷³⁵University of Tampere Tays Eye Center, Tampere, Finland. ⁷³⁶Sabiha Gokcen Ilkokulu, Ankara, Turkey. ⁷³⁷Polytechnic Institute of Porto, Porto, Portugal. ⁷³⁸Icahn School of Medicine at Mount Sinai, New York City, NY, USA. ⁷³⁹George Washington University, Washington, DC, USA. ⁷⁴⁰Universidad CEU San Pablo, Madrid, Spain. ⁷⁴¹Institute of Clinical Physiology of National Research Council, Pisa, Italy. ⁷⁴²Universidad San Francisco de Quito, Quito, Ecuador. ⁷⁴³University Miguel Hernandez, Alicante, Spain.

⁷⁴⁴Université de Lorraine, Nancy, France. ⁷⁴⁵Sunflower Nursery School, Craiova, Romania. ⁷⁴⁶North Karelia Center for Public Health, Joensuu, Finland. ⁷⁴⁷University of the Witwatersrand, Johannesburg, South Africa. ⁷⁴⁸Institute for Medical Research, Kuala Lumpur, Malaysia. ⁷⁴⁹Xinjiang Medical University, Urumqi, China. ⁷⁵⁰Shanghai Educational Development Co. Ltd, Shanghai, China. ⁷⁵¹Ministry of Health and Welfare, Taipei, Taiwan. ⁷⁵²Ministry of Health and Wellness, Kingston, Jamaica. ⁷⁵³Örebro University, Örebro, Sweden. ⁷⁵⁴St George's, University of London, London, UK. ⁷⁵⁵Universitas Indonesia, Jakarta, Indonesia. ⁷⁵⁶Rehamed-Center, Tajęcina, Poland. ⁷⁵⁷National Yang Ming Chiao Tung University, Taipei, Taiwan. ⁷⁵⁸Institute of Food and Nutrition Development of Ministry of Agriculture and Rural Affairs, Beijing, China. ⁷⁵⁹Beijing Institute of Ophthalmology, Beijing, China. ⁷⁶⁰Children's Hospital of Fudan University, Shanghai, China. ⁷⁶¹University of Cyprus, Nicosia, Cyprus. ⁷⁶²Niigata University, Niigata, Japan.

⁷⁶³South China Institute of Environmental Sciences, Guangzhou, China. ⁷⁶⁴International Medical University, Shah Alam, Malaysia. ⁷⁶⁵Hellenic Mediterranean University, Heraklion, Greece. ⁷⁶⁶Iran University of Medical Sciences, Tehran, Iran. ⁷⁶⁷Center for Diabetes and Endocrine Care, Srinagar, India. ⁷⁶⁸Jagiellonian University, Kraków, Poland. ⁷⁶⁹Duke University, Durham, NC, USA. ⁷⁷⁰Peking University First Hospital, Beijing, China. ⁷⁷¹Jiangsu Provincial Center for Disease Control and Prevention, Nanjing, China. ⁷⁷²West Kazakhstan Medical University, Aktobe, Kazakhstan. ⁷⁷³Inner Mongolia Medical University, Hohhot, China. ⁷⁷⁴Przedszkole No. 81, Warsaw, Poland. ⁷⁷⁵Johns Hopkins University, Baltimore, MD, USA. ⁷⁷⁶These authors contributed equally: Anu Mishra, Bin Zhou, Andrea Rodríguez-Martinez, Honor Bixby. ⁷⁷⁷Deceased: Konrad Jamrozik, Altan Onat, Robespierre Ribeiro, Michael Sjöström, Agustinus Soemantri, Jutta Stieber, Dimitrios Trichopoulos. ⁵³e-mail: majid.ezzati@imperial.ac.uk

Methods

We estimated trends in mean height and BMI for children and adolescents aged 5–19 years from 1990 to 2020 by rural and urban place of residence for the 200 countries and territories listed in Supplementary Table 1. We pooled, in a Bayesian meta-regression, repeated cross-sectional population-based data on height and BMI. Our results represent estimates of height and BMI for children and adolescents of the same age over time (that is, for successive cohorts) in rural and urban settings for each country.

Data sources

We used a database on cardiometabolic risk factors collated by NCD-RisC. Data were obtained from publicly available multi-country and national measurement surveys, for example, Demographic and Health Surveys (DHS), WHO-STEPwise approach to Surveillance (STEPS) surveys, and those identified through the Inter-University Consortium for Political and Social Research, UK Data Service and European Health Interview & Health Examination Surveys Database. With the help of the WHO and its regional and country offices as well as the World Heart Federation, we identified and accessed population-based survey data from national health and statistical agencies. We searched and reviewed published studies as previously detailed⁵⁴ and invited eligible studies to join NCD-RisC, as we did with data holders from earlier pooled analyses of cardiometabolic risk factors^{55–58}. The NCD-RisC database is continuously updated through all the above routes and through periodic requests to NCD-RisC members to ask them to suggest additional sources in their countries.

We carefully checked that each data source met our inclusion criteria, as listed below. Potential duplicate data sources were first identified by comparing studies from the same country and year, followed by checking with NCD-RisC members that had provided data about whether the sources from the same country and year, with similar samples, were the same or distinct. If two sources were confirmed as duplicates, one was discarded. All NCD-RisC members were also periodically asked to review the list of sources from their country to verify that the included data met the inclusion criteria and were not duplicates.

For each data source, we recorded the study population, the sampling approach, the years of measurement and the measurement methods. Only data that were representative of the population were included. All data sources were assessed in terms of whether they covered the entire country, one or more subnational regions (that is one or more provinces or states, more than three cities, or more than five rural communities), or one or a small number of communities (limited geographical scope not meeting above national or subnational criteria), and whether participants in rural, urban or both areas were included. As stated in the sections on the statistical model, these study-level attributes were used in the Bayesian hierarchical model to estimate mean height and BMI by country, year, sex, age and place of residence using all available data while taking into account differences in the populations from which different studies had sampled. All submitted data were checked by at least two independent individuals. Questions and clarifications were discussed with NCD-RisC members and resolved before data were incorporated into the database.

Anonymized individual data from the studies in the NCD-RisC database were re-analysed according to a common protocol. We calculated the mean height and the mean BMI, and the associated standard errors, by sex, single year of age from 5 to 19 years and rural or urban place of residence. Additionally, for analysis of height, participants aged 20–30 years were included, assigned to their corresponding birth cohort, because mean height in these ages would be at least that when they were aged 19 years given that the decline in height with age begins in the third and fourth decades of life⁵⁹. All analyses incorporated sample weights and complex survey design, when applicable,

in calculating summary statistics. For studies that had used simple random sampling, we calculated the mean as the average of all individuals within the group and the associated standard error (s.d. divided by the square root of sample size); for studies that had used multistage (stratified) sampling, we accounted for survey design features, including clusters, strata and sample weights, to weight each observation by the inverse sampling probability and estimated standard error through Taylor series linearization, as implemented in the R ‘survey’ package⁶⁰. Computer code was provided to NCD-RisC members who requested assistance. For surveys without information on the place of residence, we calculated summary statistics stratified by age and sex for the entire sample, which represented the population-weighted sum of rural and urban means; data on the share of population in urban and rural areas were from the United Nations Population Division⁶¹.

Additionally, summary statistics for nationally representative data from sources that were identified but not accessed using the above routes were extracted from published reports. Data were also extracted for two STEPS surveys that were not publicly available. We also included data from a previous global-data pooling study⁵⁸, when not accessed through the above routes.

Data inclusion and exclusion

Data sources were included in the NCD-RisC height and weight database if the following criteria were met: measured data on height and weight were available; study participants were 5 years of age or older; data were collected using a probabilistic sampling method with a defined sampling frame; data were from population samples at the national, subnational or community level as defined above; and data were from the countries and territories listed in Supplementary Table 1.

We excluded all data sources that were solely based on self-reported weight and height without a measurement component because these data are subject to biases that vary by geography, time, age, sex and socioeconomic characteristics^{62–64}. Owing to these variations, approaches to correcting self-reported data may leave residual bias. We also excluded data sources on population subgroups for which anthropometric status may differ systematically from the general population, including the following: studies that had included or excluded people based on their health status or cardiovascular risk; studies in which participants were only ethnic minorities; specific educational, occupational or socioeconomic subgroups (with the exception noted below); those recruited through health facilities (with the exception noted below); and females aged 15–19 years in surveys that sampled only ever-married women or measured height and weight only among mothers.

We used school-based data in countries and age–sex groups with school enrolment of 70% or higher. We used data for which the sampling frame was health insurance schemes in countries where at least 80% of the population were insured. Finally, we used data collected through general practice and primary care systems in high-income and central European countries with universal insurance because contact with the primary care systems tends to be as good as or better than response rates for population-based surveys.

We excluded participants whose age was <18 years and whose data were not reported by single year of age (<0.01% of all participants) because height and weight may have nonlinear age associations in these ages, especially during growth spurts. We excluded BMI data for females who were pregnant at the time of measurement (<0.01% of all participants). We excluded <0.2% of all participants who had recorded height: <60 cm or >180 cm for ages <10 years; <80 cm or >200 cm for ages 10–14 years; <100 cm or >250 cm for ages ≥15 years, or who had recorded weight: <5 kg or >90 kg for age <10 years; <8 kg or >150 kg for ages 10–14 years; <12 kg or >300 kg for ages ≥15 years, or who had recorded BMI: <6 kg m⁻² or >40 kg m⁻² for ages <10 years; <8 kg m⁻² or >60 kg m⁻² for ages 10–14 years; <10 kg m⁻² or >80 kg m⁻² for ages ≥15 years.

Conversion of BMI prevalence metrics to mean BMI

In 0.5% of our data points, mostly extracted from published reports or from a previous pooling analysis⁵⁸, the mean BMI was not reported but data were available for the prevalence of one or more BMI categories, for example BMI ≥ 30 kg m⁻². To use these data, we used previously validated conversion regressions⁶⁵ to estimate the missing primary outcome from the available BMI prevalence metric or metrics. Additional details on regression model specifications along with the regression coefficients are reported at <https://github.com/NCD-RisC/ncdrisc-methods/>.

Statistical model overview

We used a Bayesian hierarchical meta-regression model to estimate the mean height and BMI by country, year, sex, age and place of residence using the aforementioned data. For presentation, we summarized the 15 age-specific estimates, for single years of age from 5 to 19 years, through age standardization, which puts the child and adolescent population for each country-year on the same age distribution, and hence enables comparisons to be made over time and across countries. We generated age-standardized estimates by taking weighted means of age-specific estimates using age weights from the WHO standard population⁶⁶. We also show results, graphically and numerically, for index ages of 5, 10, 15 and 19 years in the Supplementary Information.

The statistical model is described in detail in statistical papers^{67,68}, related substantive papers^{7,20,21,55–58,65,69} and in the section below on model specification. 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 from other countries, especially those in the same region and super-region, with data for similar time periods. The extent to which estimates for each country-year were influenced by data from other years and other countries depended on whether the country had data, the sample size of the data, whether they were national, and the within-country and within-region variability of the available data. For the purpose of hierarchical analysis, countries and territories were organized into 21 regions, mostly based on geography and national income (Supplementary Table 1). Regions were in turn organized into nine super-regions.

We used observation year, that is, the year in which data were collected, as the timescale for the analysis of BMI and birth year as the timescale for the analysis of height, consistent with previous analyses^{7,65,70}. Time trends were modelled through a combination of a linear term, to capture gradual long-term change, and a second-order random walk, which allows for nonlinear trends⁷¹, both modelled hierarchically. The age associations of height and BMI were modelled, using cubic splines, to allow for nonlinear changes over age, including periods of rapid and slow rise. Periods of rapid rise representing adolescent growth spurts, which occur earlier in girls than boys^{72–74}, were reflected in the placement of spline knots for boys and girls, respectively, as detailed in the section on model specification. Spline coefficients were allowed to vary across countries, informed by their own data as well as data from other countries as specified by a hierarchical structure, as previously described⁶⁹.

The model also accounted for the possibility that height or BMI in subnational and community samples might differ systematically from nationally representative samples and have larger variation than in national studies. These features were accounted for through the inclusion of fixed-effect and random-effect terms for subnational and community data as detailed in the model specification section below. The fixed effects accounted for systematic differences between subnational or community studies and national studies. The inclusion of random effects allowed national data to have greater influence on the estimates than subnational or community data with similar sample sizes because the subnational and community data have additional variance from

the random-effect terms. Both were estimated empirically as a part of model fitting.

Following the approach of previous papers^{20,21,67}, the model included parameters representing the urban–rural height or BMI difference, which is empirically estimated and allowed to vary by country and year. We further expanded the model to allow urban–rural difference in height or BMI to vary by age, as height or weight with age may vary between children residing in rural versus urban areas. If data for a country-year-age group contained a mix of children living in urban and rural areas but were not stratified by place of residence (21% of all data sources), the estimated height or BMI difference was informed by stratified data from other age groups, years and countries, especially those in the same region with data from similar time periods and/or ages.

Statistical model specification

As stated earlier, for each data source, we calculated mean height and BMI, together with corresponding standard errors, stratified by sex, age and rural or urban place of residence. For sources that did not stratify the sample on the place of residence, we obtained age- and sex-stratified data. Each study contributed up to 30 mean BMI data points or 32 mean height data points for each sex, with the exact number depending on how many age groups were represented in the study and whether the study provided data stratified on urban and rural place of residence. The likelihood for an observation at urbanicity level s (urban-only, rural-only or mixed; referred to as stratum hereafter) and age group h , with age z_h , from study i , carried out in country j at time t is as follows:

$$y_{s,h,i} \sim N(a_{j[t]} + b_{j[t]}t_i + u_{j[t],t_i} + \gamma_i(z_h) + \mathbf{X}_i\boldsymbol{\beta} + e_i + I_{s,i}[p_{j[t]} + q_{j[t]}t_i + r_{j[t]}z_h + d_i], \text{SD}_{s,h,i}^2/n_{s,h,i} + \tau^2),$$

where the country-specific intercept and linear time slope from the j th country ($j = 1 \dots J$, where $J = 200$ which is the total number of countries in our analysis) are denoted a_j and b_j , respectively. We describe the hierarchical model used for the a 's and b 's in the section 'Linear components of country time trends'. Letting $T = 31$ be the total number of years from 1990 to 2020, the T -length vector u_j captures smooth nonlinear change over time in country j , as described in the section 'Non-linear change'. The age effects of the h th age group (with age z_h) in study i are denoted by γ_i ; we describe the age model in the section 'Age model'. The matrix \mathbf{X} contains terms describing whether studies were representative at the national, subnational or community level. In addition, a random effect, e_i , is estimated for each study, described in the section 'Study-level term and study-specific random effects'.

Linear components of country time trends. The model had a hierarchical structure, whereby studies were nested in countries, which were nested in regions (indexed by k), which were nested in super-regions (indexed by l), which were all nested in the globe (see Supplementary Table 1 for a list of countries and territories in each region, and regions in each super-region). This structure allowed the model to share information across units to a greater degree when data were non-existent or weakly informative (for example, had a small sample size or were not nationally representative) and, to a lesser extent, in data-rich countries and regions⁷⁵.

The a and b terms are country-specific linear intercepts and time slopes with terms at each level of the hierarchy, denoted by the super-scripts c , r , s and g , respectively:

$$\begin{aligned} a_j &= a_j^c + a_{k[l]}^r + a_{l[k]}^s + a_j^g, \\ b_j &= b_j^c + b_{k[l]}^r + b_{l[k]}^s + b_j^g, \\ a_j^x &\sim N(\mathbf{0}, \kappa_a^x), \\ b_j^x &\sim N(\mathbf{0}, \kappa_b^x), \end{aligned}$$

where $x = \{c, r, s\}$.

Article

The κ terms were each assigned a flat prior on the s.d. scale⁷⁶. We also assigned flat priors to a^g and b^g .

Nonlinear change. Mean BMI or height may change nonlinearly over time^{74,58,65,70}. We captured smooth nonlinear change in time in urban and rural strata of country j using the vector u_j . Just as a_j and b_j are each defined as the sum of country, region, super-region and global components, we defined

$$u_j = u_j^c + u_{k[j]}^r + u_{l[k]}^s + u^g.$$

To allow the model to differentiate between the degrees of nonlinearity that exist at the country, region, super-region and global levels, we assigned the four components of each u a Gaussian autoregressive prior^{71,77}. In particular, the T vectors u_j^c ($j=1\dots J$), u_k^r ($k=1\dots K$), u_l^s ($l=1\dots L$) and u^g each have a normal prior with mean zero and precision $\lambda_c P$, $\lambda_r P$, $\lambda_s P$ and $\lambda_g P$, respectively, where the scaled precision matrix P in the Gaussian autoregressive prior penalizes first and second differences as follows:

$$P = \begin{bmatrix} 1 & 0 & 0 & \dots & 0 \\ -2 & 1 & 0 & \dots & 0 \\ 1 & -2 & 1 & \dots & 0 \\ 0 & 1 & -2 & \dots & 0 \\ 0 & 0 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 1 \end{bmatrix} \begin{bmatrix} 1 & -2 & 1 & 0 & 0 & \dots & 0 \\ 0 & 1 & -2 & 1 & 0 & \dots & 0 \\ 0 & 0 & 1 & -2 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \dots & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & -2 & 1 & 0 & 0 & \dots & 0 \\ -2 & 5 & -4 & 1 & 0 & \dots & 0 \\ 1 & -4 & 6 & -4 & 1 & \dots & 0 \\ 0 & 1 & -4 & 6 & -4 & \dots & 0 \\ 0 & 0 & 1 & -4 & 6 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \dots & 1 \end{bmatrix}.$$

P is multiplied by the estimated precision parameters λ_c , λ_r , λ_s and λ_g , thus upweighting or downweighting the strength of its penalties and ultimately determining the degree of smoothing at each level. For each of the four precision parameters, we used a truncated flat prior on the s.d. scale ($1/\sqrt{\lambda}$)⁷⁶. We truncated these priors such that $\log \lambda \leq 20$ for each of the four λ 's. This upper bound is enforced as a computational convenience, whereby models with $\log \lambda > 20$ are treated as equivalent to a model with $\log \lambda = 20$ as they essentially have no extralinear variability in time. In practice, this upper bound had little effect on the parameter estimates. Furthermore, we ordered the λ 's a priori as follows: $\lambda_c < \lambda_r < \lambda_s < \lambda_g$. This prior constraint conveys the natural expectation that, for example, the global height or BMI trend has less extralinear variability than the trend of any given region, which in turn has less variability than those of constituent countries.

The matrix P has rank $T - 2$, corresponding to a flat, improper prior on the mean and the slope of the u_j^c 's, the u_k^r 's and the u_l^s 's and u^g , and is not invertible⁷⁸. Thus, we had a proper prior in a reduced-dimension space⁷¹, with the prior expressed as follows:

$$P(u_j^c | \lambda_c) \propto \lambda_c^{\frac{T-2}{2}} \exp\left\{-\frac{\lambda_c}{2} u_j^c P u_j^c\right\}.$$

Note that if u_j^c had a non-zero mean, this would introduce non-identifiability with respect to a_j^c . By the same token, b_j^c would not be identifiable if u_j had a non-zero time slope, and similarly for the other means and slopes. Thus, to achieve identifiability of the a 's, b 's, and u 's, we constrained the mean and slope of u^g and of each u^s , u^r and u^c to be zero. Enforcing orthogonality between the linear and nonlinear portions of the time trends meant that each can be interpreted independently.

For the cases in which we have observations for at least two different time points, this improper prior will not lead to an improper posterior

because the data will provide information about the mean and slope. In order to enforce the desired orthogonality between the linear and nonlinear portions of the model, we constrained the mean and slope of the u_j^c 's, u_k^r 's and u_l^s 's and of u^g to be zero⁷¹.

For the six countries with no height data, and seven countries with no BMI data, we took the Moore–Penrose pseudoinverse of P ⁷⁹, setting to infinity those eigenvalues that correspond to the non-identifiability. This effectively constrained the non-identified portions of the model to zero, as the corresponding variances are set to zero⁷⁷; in this case the Rue and Held correction⁷¹ is not needed. An intermediate case occurs when data are observed for only one time point in a country. In this case, the full conditional precision has rank $T - 1$ because the mean but not the linear trend of u_j^c is identified by the data. We therefore constrained the linear trend of u_j^c to zero by taking the generalized inverse of the full conditional precision. We then constrained the mean of u_j^c to zero using the one-dimensional version of the Rue and Held correction⁷¹.

Age model. To capture sex-specific patterns of growth, especially adolescent growth spurts, we modelled age using cubic splines. The number and position of the knots of the splines were selected on the basis of a combination of physiological and statistical considerations, as described in a national level analysis⁷. For age group h with age z_h , in study i , the age effect for height and BMI is given, respectively, as follows:

$$Y_i(z_h) = \gamma_{1i} z_h + \gamma_{2i} z_h^2 + \gamma_{3i} z_h^3 + \gamma_{4i} (z_h - k_1)_+^3 + \gamma_{5i} (z_h - k_2)_+^3 + \gamma_{6i} (z_h - k_3)_+^3 + \gamma_{7i} (z_h - k_4)_+^3, \quad (\text{height})$$

$$Y_i(z_h) = \gamma_{1i} z_h + \gamma_{2i} z_h^2 + \gamma_{3i} z_h^3 + \gamma_{4i} (z_h - k_1)_+^3 + \gamma_{5i} (z_h - k_2)_+^3. \quad (\text{BMI})$$

For height, four spline knots were placed at ages $\{k_1, k_2, k_3, k_4\} = \{8, 10, 12, 14\}$ for girls and at ages $\{k_1, k_2, k_3, k_4\} = \{10, 12, 14, 16\}$ for boys. For BMI, we used two spline knots (at ages 10 and 15 years) because, at the population level, changes in BMI with age are smoother than those in height^{77,73}. Each of the spline coefficients was allowed to vary across countries, with a hierarchical structure as described in a previous paper⁶⁹, using the equation below, where ψ is the global intercept, and c , r and s are the country, region and super-region random intercepts, respectively. The k th age effect coefficients for study i ($\gamma_{k,i}$) for each age group h , with age z_h , are given as follows:

$$\begin{aligned} \gamma_{k,i} &= \psi_k + c_{k,j[i]} + r_{k,l[i]} + s_{k,m[l]i} \\ c_{k,j} &\sim N(0, \sigma_{k,c}^2), \\ r_{k,l} &\sim N(0, \sigma_{k,r}^2), \\ s_{k,l} &\sim N(0, \sigma_{k,s}^2). \end{aligned}$$

A flat improper prior was placed on each of the σ_k 's.

Study-level term and study-specific random effects. Mean height or BMI from individual studies may deviate from the true country-year mean owing to factors associated with sampling, response or measurement. We used a study-level term to help account for potential systematic differences associated with data sources that are representative of subnational and community populations. Our model therefore included time-varying offsets (referred to as fixed effects above) for subnational and community data in the term $X_i \beta$:

$$X_i \beta = \beta_1 I\{X_{j[i],t[i]}^{\text{cvtg}} = \text{subnational}\} + \beta_2 I\{X_{j[i],t[i]}^{\text{cvtg}} = \text{subnational}\} t_i + \beta_3 I\{X_{j[i],t[i]}^{\text{cvtg}} = \text{community}\} + \beta_4 I\{X_{j[i],t[i]}^{\text{cvtg}} = \text{community}\} t_i,$$

where $X_{j[i],t[i]}^{\text{cvtg}}$ is the indicator for whether the coverage of study i , in country j and year t , is subnational or community.

Even after accounting for sampling variability, national studies may still not reflect the true mean height or BMI level of a country with perfect accuracy, and subnational and community studies have even larger variability. In study i , the study-specific random effect e_i allows all age groups from the same study to have an unusually high or an unusually low mean after conditioning on the other terms in the model. Each e_i is assigned a normal prior with variance depending on whether study i is representative at the national, subnational or community level. Random effects from national studies were constrained to have smaller variance (v_n) than random effects of subnational studies (v_s), which were in turn constrained to have smaller variance than community studies (v_c). To make country-level predictions, we set $e_i = 0$, thus not including random effects arising from imperfections and variations in study design and implementation and from within-country variability of height or BMI means.

Urban and rural strata. To model mean height and BMI by urban and rural places of residence, the model included offsets for the two strata. The offsets were captured by country-specific intercept, linear time and age effects, using a centred indicator term ($I_{s,i}$):

$$I_{s,i}[p_{j[i]} + q_{j[i]}t_i + r_{j[i]}z_h + d_i],$$

where $I_{s,i} = -1 + 2X_{s,i}^{\text{urb}}$, with

$$X_{s,i}^{\text{urb}} = \begin{cases} 1, & \text{if stratum } s \text{ contains only urban individuals,} \\ 0, & \text{if stratum } s \text{ contains only rural individuals,} \\ X_{j[i],t[i]}^{\text{urb}}, & \text{if stratum } s \text{ contains a mixture of} \\ & \text{urban and rural individuals.} \end{cases}$$

In other words, for data not stratified by place of residence, the model treated the unstratified mean height or BMI as equivalent to the weighted sum of the (unobserved) urban sample mean height or BMI and rural sample mean height or BMI, with the weights based on the proportion of the population of that country living in urban areas in the year of the survey ($X_{j[i],t[i]}^{\text{urb}}$).

The intercept (p) and slope (q) terms capture the country-to-country variation in the magnitude of the height or BMI difference between urban and rural populations and how the difference changes over time. The slope (r) captures the country-to-country variation in the BMI or height difference between urban and rural populations across age groups. These were specified with the same geographical hierarchy as the country-specific intercepts (a) and slopes (b) as follows:

$$\begin{aligned} p_j &= p_j^c + p_{k[j]}^r + p_{l[k]}^s + p^g, \\ q_j &= q_j^c + q_{k[j]}^r + q_{l[k]}^s + q^g, \\ r_j &= r_j^c + r_{k[j]}^r + r_{l[k]}^s + r^g, \\ p_j^x &\sim N(0, \kappa_p^x), \\ q_j^x &\sim N(0, \kappa_q^x), \\ r_j^x &\sim N(0, \kappa_r^x), \end{aligned}$$

where $x = \{c, r, s\}$. The study random effect term d_i incorporates deviations from the country-level urban–rural difference in each study and is analogous to e_i .

Residual age-by-study variability. The age patterns across communities within a given country may differ from the overall age pattern of that country. This within-study variability cannot be captured by the e terms, which are equal across age-specific observations in each study, so we included an additional variance component for each study, τ^2 .

Model implementation

All analyses were done separately by sex because age, geographical and temporal patterns of height and BMI differ between girls and boys⁷⁶⁵. We fitted the statistical model using Markov chain Monte Carlo (MCMC). We started 35 parallel MCMC runs from randomly generated overdispersed starting values. For computational efficiency, each chain was run for a total of 75,000 iterations. All chains converged to the same target distribution within this number, but due to the overdispersed initial values, the length of burn-in required to converge to the target distribution varied. After the runs were completed, we used trace plots to monitor convergence and to select chains that had completed burn-in within 35,000 iterations. This resulted in 16 chains for boys and 17 for girls for BMI, and 14 chains for boys and 16 for girls for height. Within each of these chains, post-burn-in iterations were thinned by keeping every 10th iteration, which were then combined for all chains and further thinned to a final set of 5,000 draws of the model parameter estimates. We used the posterior distribution of the model parameters to obtain the posterior distributions of our outcomes: mean urban and rural height and BMI, and the urban–rural difference in mean height and BMI. Posterior estimates were made for one-year age groups from 5 to 19 years, as well as for age-standardized outcomes, by year. The reported CrIs represent the 2.5th and the 97.5th percentiles of the posterior distributions. We also report the posterior s.d. of estimates, and PP that the estimated change in height or BMI in rural or urban areas, and in the urban–rural height or BMI difference over time, represents a true increase or decrease.

Convergence was confirmed for the country-sex specific posterior outcomes—namely mean urban height and BMI, mean rural height and BMI and the urban–rural difference in mean height and BMI—for reporting ages (5, 10, 15, 19 years and age-standardized) and years (1990 and 2020) using the R-hat diagnostic^{80,81}. For height, the 2.5th to 97.5th percentiles of the R-hats for the reporting ages and years were 0.999–1.010 for girls and 0.999–1.004 for boys. For BMI, the 2.5th to 97.5th percentiles of the R-hats were 0.999–1.004 for girls and 0.999–1.005 for boys.

We applied the pool-adjacent-violators algorithm, a monotonic regression that uses an iterative algorithm based on least squares to fit a free-form line to a sequence of observations such that the fitted line is non-decreasing^{82,83}, on the posterior height estimates to ensure that the height for each birth cohort increased monotonically with age. In practice, this had little effect on the results, with height at age 19 years adjusted by an average of 0.26 cm or less for both boys and girls. All analyses were conducted using the statistical software R (v.4.1.2)⁸⁴.

Strengths and limitations

An important strength of our study is its novel scope of presenting consistent and comparable estimates of urban and rural height and BMI among school-aged children and adolescents, which is essential to formulate and evaluate policies that aim to improve health in these formative ages. We used a large number of population-based studies from 194 countries and territories covering around 99% of the population of the world. We maintained a high level of data quality and representativeness through repeated checks of study characteristics against our inclusion and exclusion criteria, and did not use any self-reported data to avoid bias in height and weight. Data were analysed according to a consistent protocol, and the characteristics and quality of data from each country were rigorously verified through repeated checks by NCD-RisC members. We used a statistical model that used all available data and took into account the epidemiological features of height and BMI during childhood and adolescence by using nonlinear time trends and age associations. The model used the available information on the urban–rural difference in height and BMI and estimated the age-varying and time-varying urban–rural difference for all countries and territories hierarchically.

Article

Despite our extensive efforts to identify and access data, some countries had fewer data, especially those in the Caribbean, Polynesia, Micronesia and sub-Saharan Africa. Of the studies used, fewer than half had data for children aged 5–9 years compared to nearly 90% with data for children and adolescents aged 10–19 years. The scarcity of data is reflected in the larger uncertainty of our estimates for these countries and regions, and younger age groups. This reflects the need to systematically include school-aged children in both health and nutrition surveys, and, especially in countries where school enrolment is high, to use schools as a platform for monitoring growth and developmental outcomes for entire national populations and key subgroups such as those in rural and urban areas. Although urban and rural classifications are commonly based on definitions by national statistical offices, classification of cities and rural areas may, appropriately, vary by country according to their demographic characteristics (for example, population size or density), economic activities, administrative structures, infrastructure and environment. Similarly, urbanization takes place through a variety of mechanisms such as changes in fertility in rural and urban areas, migration and reclassification of previously rural areas to urban as they grow and industrialize. Each of these mechanisms may have different implications for nutrition and physical activity, and hence height and/or BMI, and should be a subject of studies that follow individual participants and changes in their place of residence. Finally, there is variation in growth and development of children within rural or urban areas based on household socioeconomic status and community characteristics that affect access to and the quality of nutrition, the living environment and healthcare^{35,85,86}. Among these, in some cities, a large number of families live in slums^{19,87}. School-aged children and adolescents living in slums have nutrition, environment and healthcare access that is typically worse than other residents of the city, although often better than those in rural areas^{19,87–90}.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

Estimates of mean BMI and height by country, year, sex, single year of age as well as age-standardized, and place of residence (urban and rural) will be available from <https://www.ncdrisc.org> in machine-readable numerical format and as visualizations upon publication of the paper. Input data from publicly available sources and contact information for data providers can be downloaded from <https://www.ncdrisc.org> and Zenodo (<https://doi.org/10.5281/zenodo.7355601>).

Code availability

The computer code for the Bayesian hierarchical model and the code used to generate figures in this work will be available at <https://www.ncdrisc.org> and Zenodo (<https://doi.org/10.5281/zenodo.7355601>).

54. NCD Risk Factor Collaboration (NCD-RisC). 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. *Lancet* **387**, 1377–1396 (2016).
55. Danaei, G. et al. National, regional, and global trends in systolic blood pressure since 1980: systematic analysis of health examination surveys and epidemiological studies with 786 country-years and 5.4 million participants. *Lancet* **377**, 568–577 (2011).
56. Danaei, G. et al. National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2.7 million participants. *Lancet* **378**, 31–40 (2011).
57. Farzadfar, F. et al. National, regional, and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3.0 million participants. *Lancet* **377**, 578–586 (2011).
58. Finucane, M. M. et al. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. *Lancet* **377**, 557–567 (2011).
59. Cline, M. G., Meredith, K. E., Boyer, J. T. & Burrows, B. Decline of height with age in adults in a general population sample: estimating maximum height and distinguishing birth cohort effects from actual loss of stature with aging. *Hum. Biol.* **61**, 415–425 (1989).
60. Lumley, T. Analysis of complex survey samples. *J. Stat. Softw.* **9**, 1–19 (2004).
61. United Nations Department of Economic and Social Affairs, Population Division. *World Urbanization Prospects: The 2018 Revision* (United Nations, 2019).
62. Hayes, A. J., Clarke, P. M. & Lung, T. W. Change in bias in self-reported body mass index in Australia between 1995 and 2008 and the evaluation of correction equations. *Popul. Health Metr.* **9**, 53 (2011).
63. Connor Gorber, S., Tremblay, M., Moher, D. & Gorber, B. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes. Rev.* **8**, 307–326 (2007).
64. Ezzati, M., Martin, H., Skjold, S., Vander Hoorn, S. & Murray, C. J. L. Trends in national and state-level obesity in the USA after correction for self-report bias: analysis of health surveys. *J. R. Soc. Med.* **99**, 250–257 (2006).
65. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet* **390**, 2627–2642 (2017).
66. Ahmad, O. B. et al. *Age Standardization of Rates: A New WHO Standard* (World Health Organization, 2001).
67. Finucane, M. M., Paciorek, C. J., Stevens, G. A. & Ezzati, M. Semiparametric Bayesian density estimation with disparate data sources: a meta-analysis of global childhood undernutrition. *J. Am. Stat. Assoc.* **110**, 889–901 (2015).
68. Finucane, M. M., Paciorek, C. J., Danaei, G. & Ezzati, M. Bayesian estimation of population-level trends in measures of health status. *Stat. Sci.* **29**, 18–25 (2014).
69. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet* **398**, 957–980 (2021).
70. NCD Risk Factor Collaboration (NCD-RisC). A century of trends in adult human height. *eLife* **5**, e13410 (2016).
71. Rue, H. V. & Held, L. *Gaussian Markov Random Fields: Theory and Applications* (Chapman & Hall/CRC, 2005).
72. Cameron, N. L. *Human Growth and Development* (Academic Press, 2002).
73. de Onis, M. et al. Development of a WHO growth reference for school-aged children and adolescents. *Bull. World Health Organ.* **85**, 660–667 (2007).
74. Tanner, J. M., Whitehouse, R. H., Marubini, E. & Resele, L. F. The adolescent growth spurt of boys and girls of the Harpenden growth study. *Ann. Hum. Biol.* **3**, 109–126 (1976).
75. Gelman, A. & Hill, J. *Data Analysis Using Regression and Multilevel/Hierarchical Models* (Cambridge Univ. Press, 2007).
76. Gelman, A. Prior distributions for variance parameters in hierarchical models. *Bayesian Anal.* **1**, 515–533 (2006).
77. Breslow, N. E. & Clayton, D. G. Approximate inference in generalized linear mixed models. *J. Am. Stat. Assoc.* **88**, 9–25 (1993).
78. Wood, S. N. *Generalized Additive Models: An Introduction with R* (Chapman & Hall/CRC, 2006).
79. Harville, D. A. *Matrix Algebra from a Statistician's Perspective* (Springer-Verlag, 2008).
80. Vehtari, A., Gelman, A., Simpson, D., Carpenter, B. & Bürkner, P.-C. Rank-normalization, folding, and localization: an improved R for assessing convergence of MCMC (with discussion). *Bayesian Anal.* **16**, 667–718 (2021).
81. Stan Development Team. *RStan: the R interface to Stan* <https://mc-stan.org/> (2022).
82. Best, M. J. & Chakravarti, N. Active set algorithms for isotonic regression; a unifying framework. *Math. Program.* **47**, 425–439 (1990).
83. De Leeuw, J., Hornik, K. & Mair, P. Isotone optimization in R: pool-adjacent-violators algorithm (PAVA) and active set methods. *J. Stat. Softw.* **32**, 1–24 (2010).
84. The R Development Core Team. *R: A Language and Environment for Statistical Computing* (R Foundation for Statistical Computing, 2021).
85. Huang, R., Moudon, A. V., Cook, A. J. & Drewnowski, A. The spatial clustering of obesity: does the built environment matter? *J. Hum. Nutr. Diet.* **28**, 604–612 (2015).
86. Menon, P., Ruel, M. T. & Morris, S. S. Socio-economic differentials in child stunting are consistently larger in urban than in rural areas. *Food Nutr. Bull.* **21**, 282–289 (2000).
87. Ezeh, A. et al. The history, geography, and sociology of slums and the health problems of people who live in slums. *Lancet* **389**, 547–558 (2017).
88. Fink, G., Günther, I. & Hill, K. Slum residence and child health in developing countries. *Demography* **51**, 1175–1197 (2014).
89. Jonah, C. M. P. & May, J. D. The nexus between urbanization and food insecurity in South Africa: does the type of dwelling matter? *Int. J. Urban Sustain. Dev.* **12**, 1–13 (2020).
90. *Progress Report: Sustainable Development Goal 11 (Target 11.1)* (Habitat for Humanity International, 2019).

Acknowledgements This study was funded by the UK Medical Research Council (grant number MR/V034057/1), the Wellcome Trust (Pathways to Equitable Healthy Cities grant 209376/Z/17/Z), the AstraZeneca Young Health Programme and the European Commission (STOP project through EU Horizon 2020 research and innovation programme under Grant Agreement 774548). For the purpose of open access, the author has applied a Creative Commons Attribution (CC BY) licence to the Author Accepted Manuscript version arising from this submission. We thank W. Dietz, L. Jaacks and W. Johnson for recommendations of relevant citations. The authors alone are responsible for the views expressed in this Article and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated.

Author contributions A.M., B.Z., A.R.M., H.B. and R.K.S. led the data collection and management. A.M., B.Z., A.R.M., H.B., C.J.P., J.E.B. and M.E. developed the statistical method. A.M., B.Z., A.R.M. and H.B. coded the statistical method. A.M. conducted analyses and prepared results. The other authors contributed to study design, and collected, reanalysed, checked and pooled data. M.E., A.M., B.Z., A.R.M. and H.B. wrote the first draft of the report. All other authors commented on the draft report.

Competing interests M.E. reports a charitable grant from the AstraZeneca Young Health Programme.

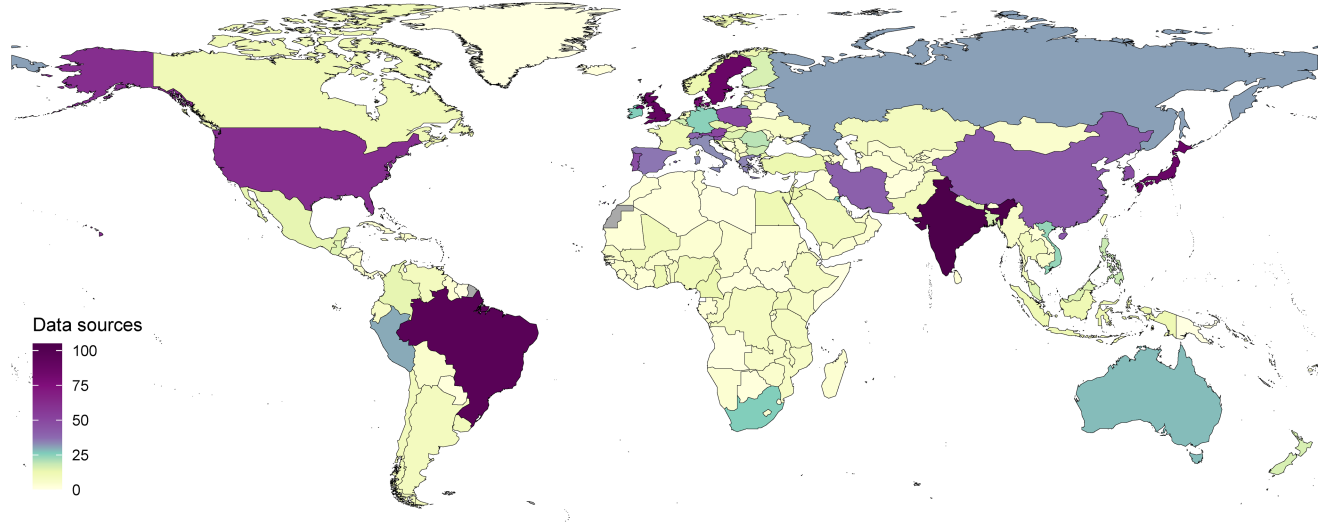
Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s41586-023-05772-8>.

Correspondence and requests for materials should be addressed to Majid Ezzati.

Peer review information *Nature* thanks Sam Harper, Jessica Jones-Smith and the other, anonymous, reviewer(s) for their contribution to the peer review of this work. Peer reviewer reports are available.

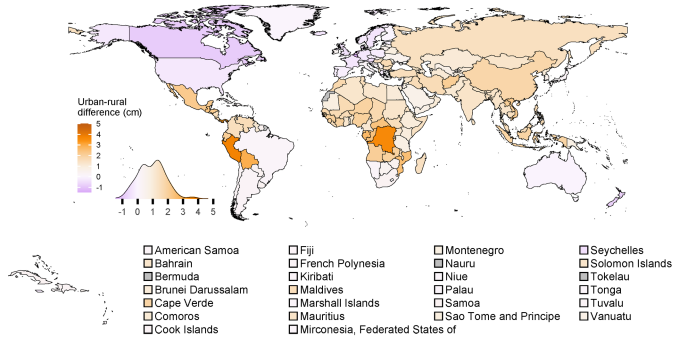
Reprints and permissions information is available at <http://www.nature.com/reprints>.



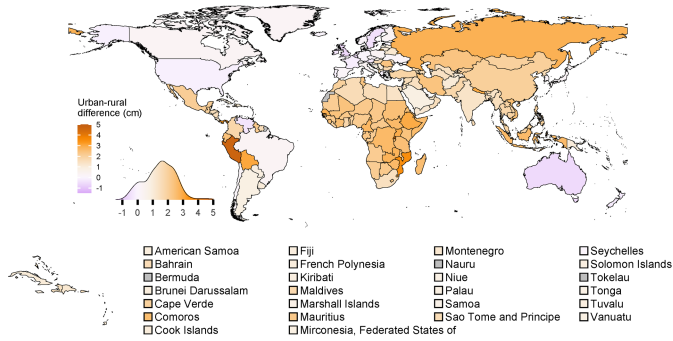
- | | | | |
|--|--|--|--|
| <input type="checkbox"/> American Samoa | <input type="checkbox"/> Fiji | <input type="checkbox"/> Montenegro | <input type="checkbox"/> Seychelles |
| <input type="checkbox"/> Bahrain | <input type="checkbox"/> French Polynesia | <input type="checkbox"/> Nauru | <input type="checkbox"/> Solomon Islands |
| <input type="checkbox"/> Bermuda | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Niue | <input type="checkbox"/> Tokelau |
| <input type="checkbox"/> Brunei Darussalam | <input type="checkbox"/> Maldives | <input type="checkbox"/> Palau | <input type="checkbox"/> Tonga |
| <input type="checkbox"/> Cape Verde | <input type="checkbox"/> Marshall Islands | <input type="checkbox"/> Samoa | <input type="checkbox"/> Tuvalu |
| <input type="checkbox"/> Comoros | <input type="checkbox"/> Mauritius | <input type="checkbox"/> Sao Tome and Principe | <input type="checkbox"/> Vanuatu |
| <input type="checkbox"/> Cook Islands | <input type="checkbox"/> Micronesia, Federated States of | | |

Extended Data Fig.1 | Number of data sources used in the analysis, by country.

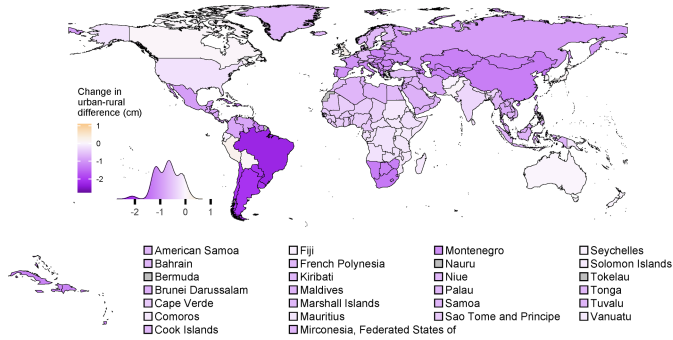
Urban-rural difference in 2020 (girls)



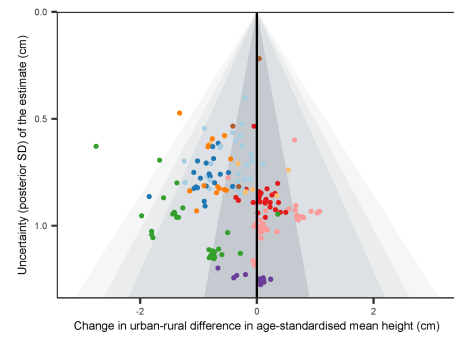
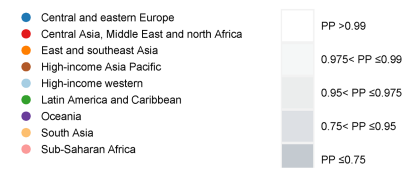
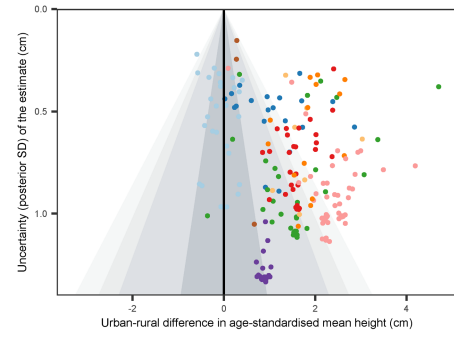
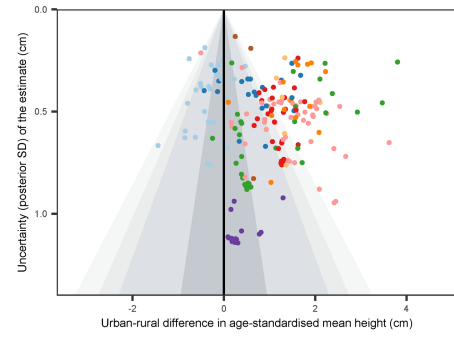
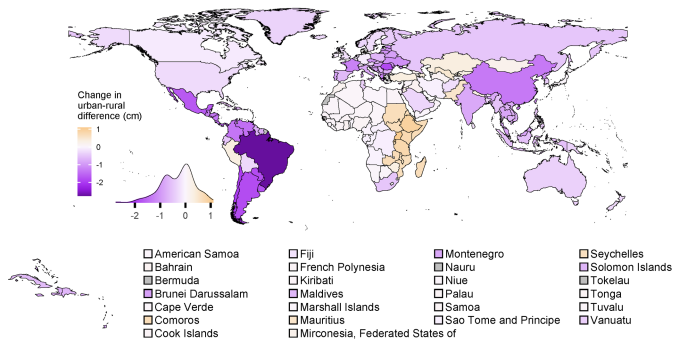
Urban-rural difference in 2020 (boys)



Change 1990-2020 (girls)



Change 1990-2020 (boys)



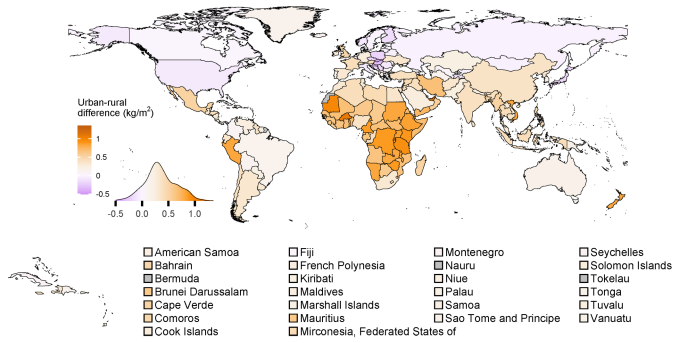
Extended Data Fig. 2 | See next page for caption.

Article

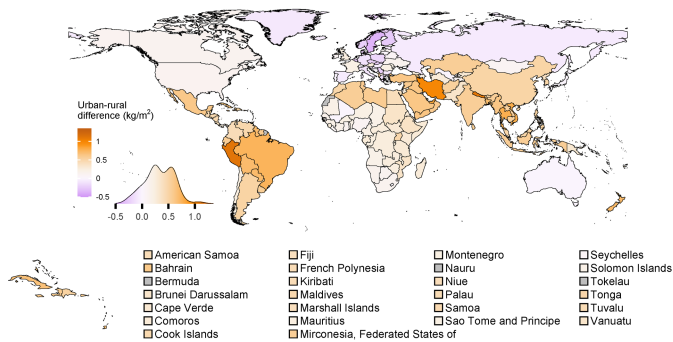
Extended Data Fig. 2 | Urban-rural height difference in 2020 and change from 1990 to 2020. The top two maps show the urban-rural difference in age-standardised mean height in 2020 for girls and boys respectively. A positive number shows higher urban mean height and a negative number shows higher rural mean height. The bottom two maps show the change from 1990 to 2020. The density plot below each map shows the distribution of estimates across countries. The top two scatter plots show the urban-rural difference in age-standardised mean height in relation to the uncertainty of the difference measured by posterior s.d. The bottom two scatter plots show the change from 1990 to 2020 in urban-rural difference in mean height in relation to the

uncertainty of the change measured by posterior s.d. Each point in the scatter plots shows one country. Shaded areas approximately show the posterior probability (PP) of a true difference (top two scatter plots) and of a true increase or decrease in difference (bottom two scatter plots). See Extended Data Fig. 8 for PPs of the urban-rural difference in age-standardised mean height and its change. See Supplementary Fig. 7 for results at ages 5, 10, 15 and 19 years. We did not estimate the difference between rural and urban height for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau), as indicated in grey.

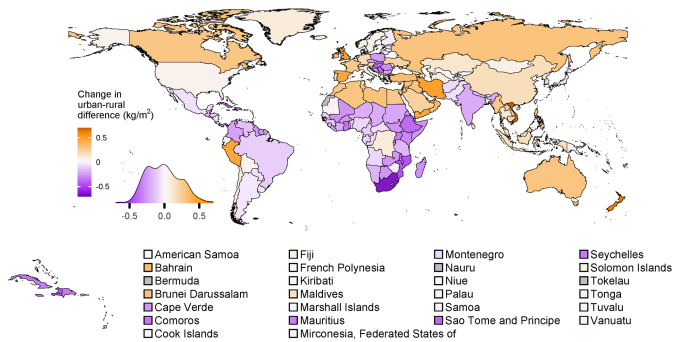
Urban-rural difference in 2020 (girls)



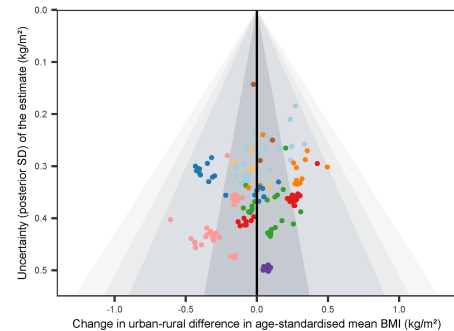
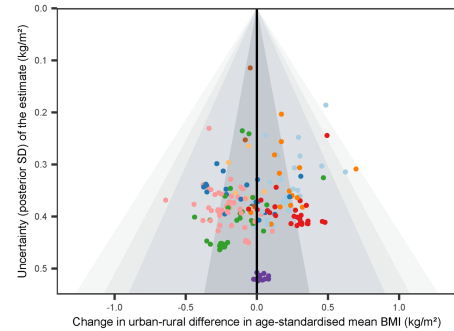
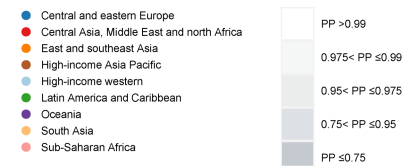
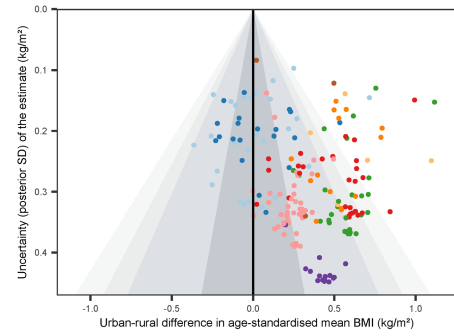
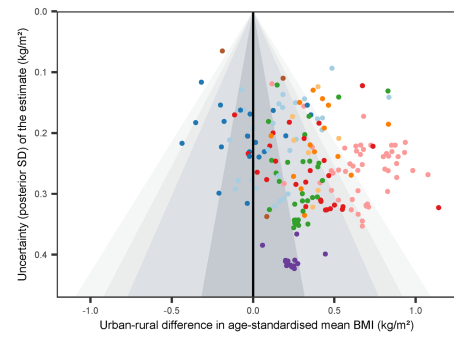
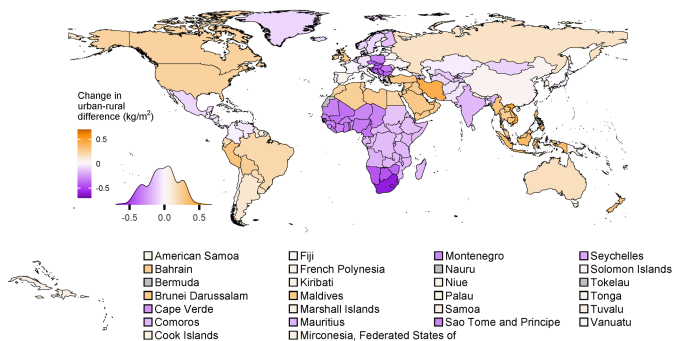
Urban-rural difference in 2020 (boys)



Change 1990-2020 (girls)



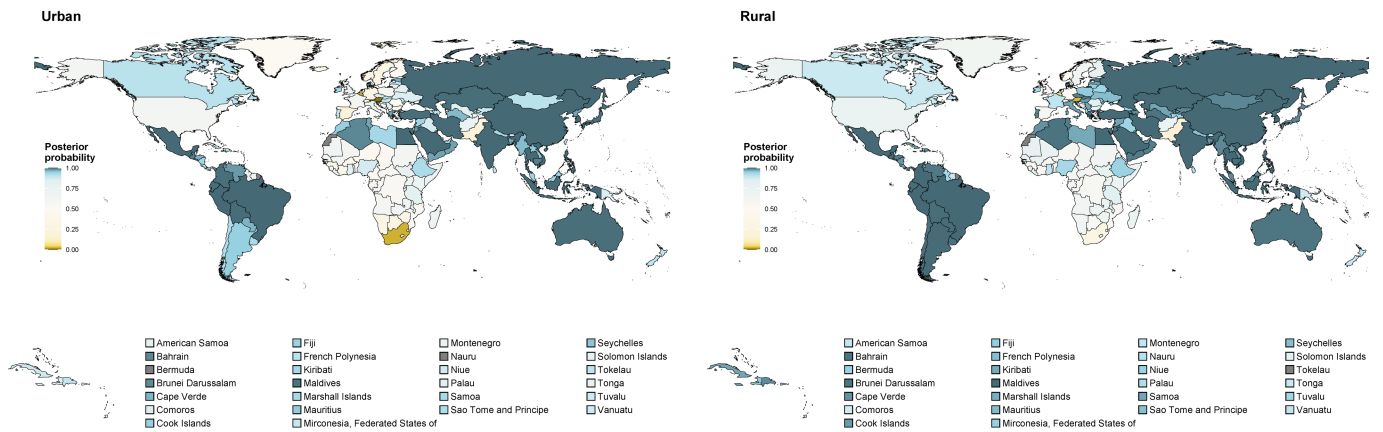
Change 1990-2020 (boys)



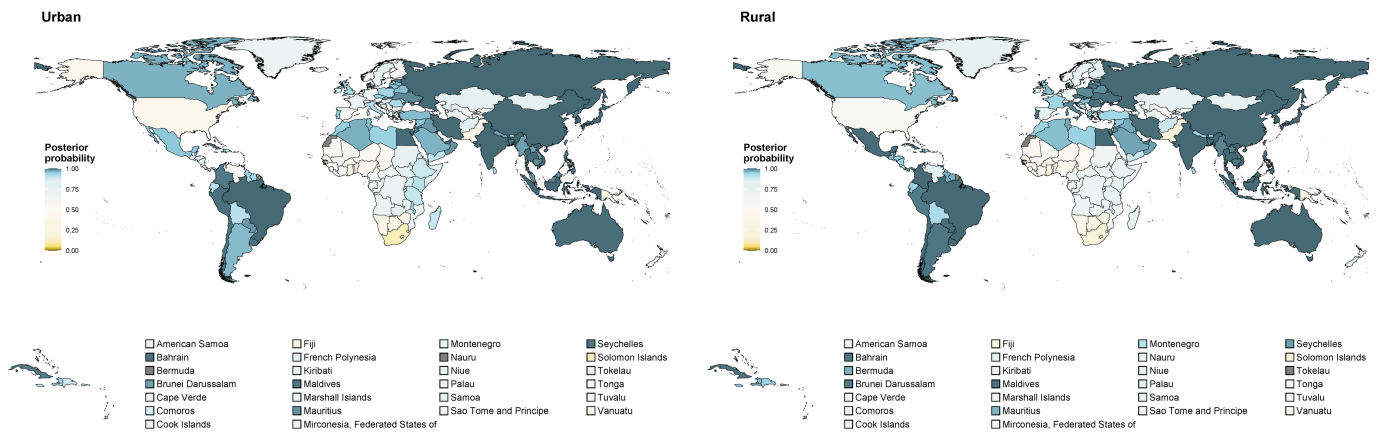
Extended Data Fig. 3 | Urban-rural body-mass index (BMI) difference in 2020 and change from 1990 to 2020. See Extended Data Fig. 2 caption for descriptions of the contents of the figure and for definitions. See Extended Data Fig. 9 for PP of the urban-rural difference in age-standardised mean BMI

and its change. See Supplementary Fig. 8 for results at ages 5, 10, 15 and 19 years. We did not estimate the difference between rural and urban BMI for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau), as indicated in grey.

Girls



Boys

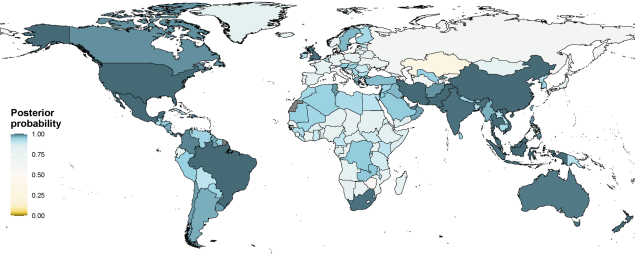


Extended Data Fig. 4 | Posterior probability of increase in mean height in urban and rural areas from 1990 to 2020. The maps show the PP that the age-standardised mean height increased from 1990 to 2020. The PP of a decrease is one minus that of an increase. If an increase in mean height is statistically indistinguishable from a decrease, the PP is 0.50. PPs closer to 0.50 indicate

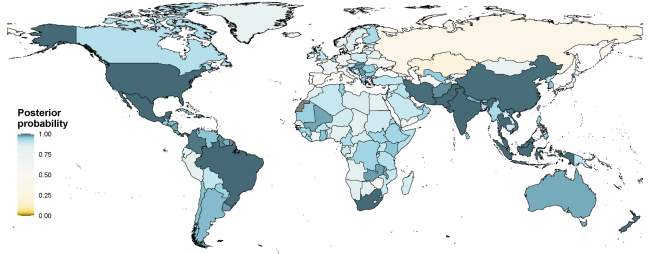
more uncertainty, those towards 1 indicate more certainty of an increase, and those towards 0 indicate more certainty of a decrease. We did not estimate PP for change in mean rural height for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or change in mean urban height for countries classified as entirely rural (Tokelau), as indicated in grey.

Girls

Urban



Rural

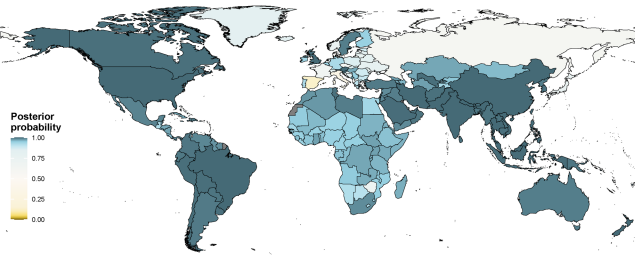


- | | | | |
|--|--|--|--|
| <input type="checkbox"/> American Samoa | <input type="checkbox"/> Fiji | <input type="checkbox"/> Montenegro | <input type="checkbox"/> Seychelles |
| <input type="checkbox"/> Bahrain | <input type="checkbox"/> French Polynesia | <input type="checkbox"/> Nauru | <input type="checkbox"/> Solomon Islands |
| <input type="checkbox"/> Bermuda | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Niue | <input type="checkbox"/> Tokelau |
| <input type="checkbox"/> Brunei Darussalam | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Palau | <input type="checkbox"/> Tonga |
| <input type="checkbox"/> Cape Verde | <input type="checkbox"/> Marshall Islands | <input type="checkbox"/> Samoa | <input type="checkbox"/> Tuvalu |
| <input type="checkbox"/> Comoros | <input type="checkbox"/> Mauritius | <input type="checkbox"/> Sao Tome and Principe | <input type="checkbox"/> Vanuatu |
| <input type="checkbox"/> Cook Islands | <input type="checkbox"/> Micronesia, Federated States of | | |

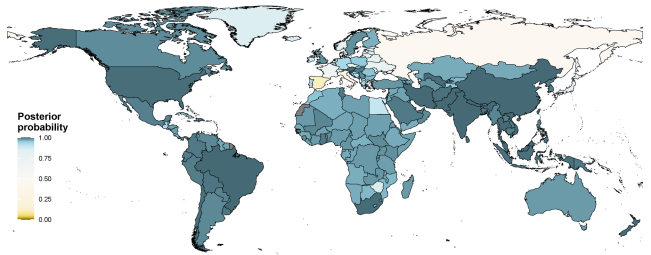
- | | | | |
|--|--|--|--|
| <input type="checkbox"/> American Samoa | <input type="checkbox"/> Fiji | <input type="checkbox"/> Montenegro | <input type="checkbox"/> Seychelles |
| <input type="checkbox"/> Bahrain | <input type="checkbox"/> French Polynesia | <input type="checkbox"/> Nauru | <input type="checkbox"/> Solomon Islands |
| <input type="checkbox"/> Bermuda | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Niue | <input type="checkbox"/> Tokelau |
| <input type="checkbox"/> Brunei Darussalam | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Palau | <input type="checkbox"/> Tonga |
| <input type="checkbox"/> Cape Verde | <input type="checkbox"/> Marshall Islands | <input type="checkbox"/> Samoa | <input type="checkbox"/> Tuvalu |
| <input type="checkbox"/> Comoros | <input type="checkbox"/> Mauritius | <input type="checkbox"/> Sao Tome and Principe | <input type="checkbox"/> Vanuatu |
| <input type="checkbox"/> Cook Islands | <input type="checkbox"/> Micronesia, Federated States of | | |

Boys

Urban



Rural

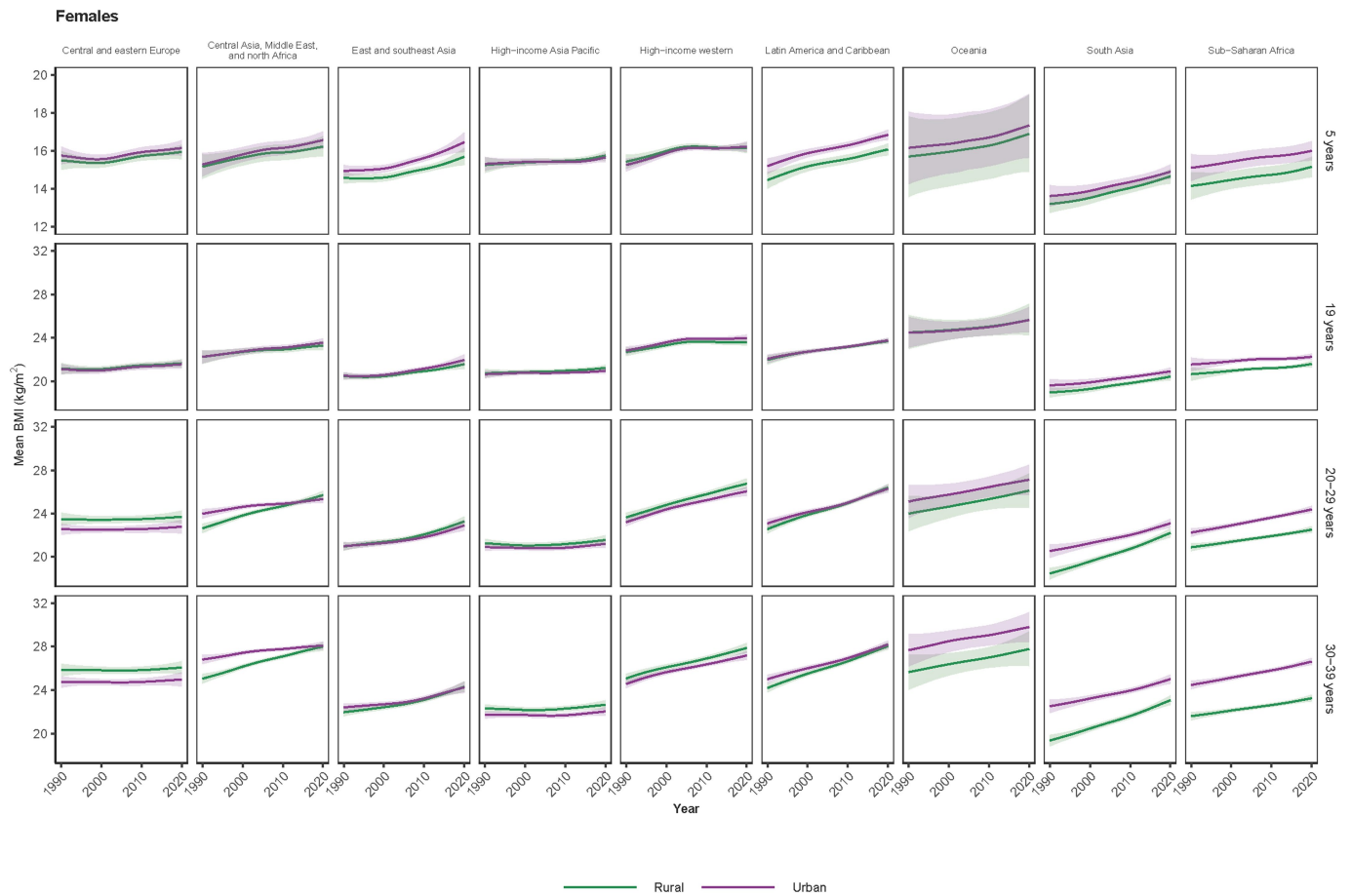


- | | | | |
|--|--|--|--|
| <input type="checkbox"/> American Samoa | <input type="checkbox"/> Fiji | <input type="checkbox"/> Montenegro | <input type="checkbox"/> Seychelles |
| <input type="checkbox"/> Bahrain | <input type="checkbox"/> French Polynesia | <input type="checkbox"/> Nauru | <input type="checkbox"/> Solomon Islands |
| <input type="checkbox"/> Bermuda | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Niue | <input type="checkbox"/> Tokelau |
| <input type="checkbox"/> Brunei Darussalam | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Palau | <input type="checkbox"/> Tonga |
| <input type="checkbox"/> Cape Verde | <input type="checkbox"/> Marshall Islands | <input type="checkbox"/> Samoa | <input type="checkbox"/> Tuvalu |
| <input type="checkbox"/> Comoros | <input type="checkbox"/> Mauritius | <input type="checkbox"/> Sao Tome and Principe | <input type="checkbox"/> Vanuatu |
| <input type="checkbox"/> Cook Islands | <input type="checkbox"/> Micronesia, Federated States of | | |

- | | | | |
|--|--|--|--|
| <input type="checkbox"/> American Samoa | <input type="checkbox"/> Fiji | <input type="checkbox"/> Montenegro | <input type="checkbox"/> Seychelles |
| <input type="checkbox"/> Bahrain | <input type="checkbox"/> French Polynesia | <input type="checkbox"/> Nauru | <input type="checkbox"/> Solomon Islands |
| <input type="checkbox"/> Bermuda | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Niue | <input type="checkbox"/> Tokelau |
| <input type="checkbox"/> Brunei Darussalam | <input type="checkbox"/> Kiribati | <input type="checkbox"/> Palau | <input type="checkbox"/> Tonga |
| <input type="checkbox"/> Cape Verde | <input type="checkbox"/> Marshall Islands | <input type="checkbox"/> Samoa | <input type="checkbox"/> Tuvalu |
| <input type="checkbox"/> Comoros | <input type="checkbox"/> Mauritius | <input type="checkbox"/> Sao Tome and Principe | <input type="checkbox"/> Vanuatu |
| <input type="checkbox"/> Cook Islands | <input type="checkbox"/> Micronesia, Federated States of | | |

Extended Data Fig. 5 | Posterior probability of increase in mean body-mass index (BMI) in urban and rural areas from 1990 to 2020. The maps show the posterior probability (PP) that the age-standardised mean BMI increased from 1990 to 2020. The PP of a decrease is one minus that of an increase. We did not

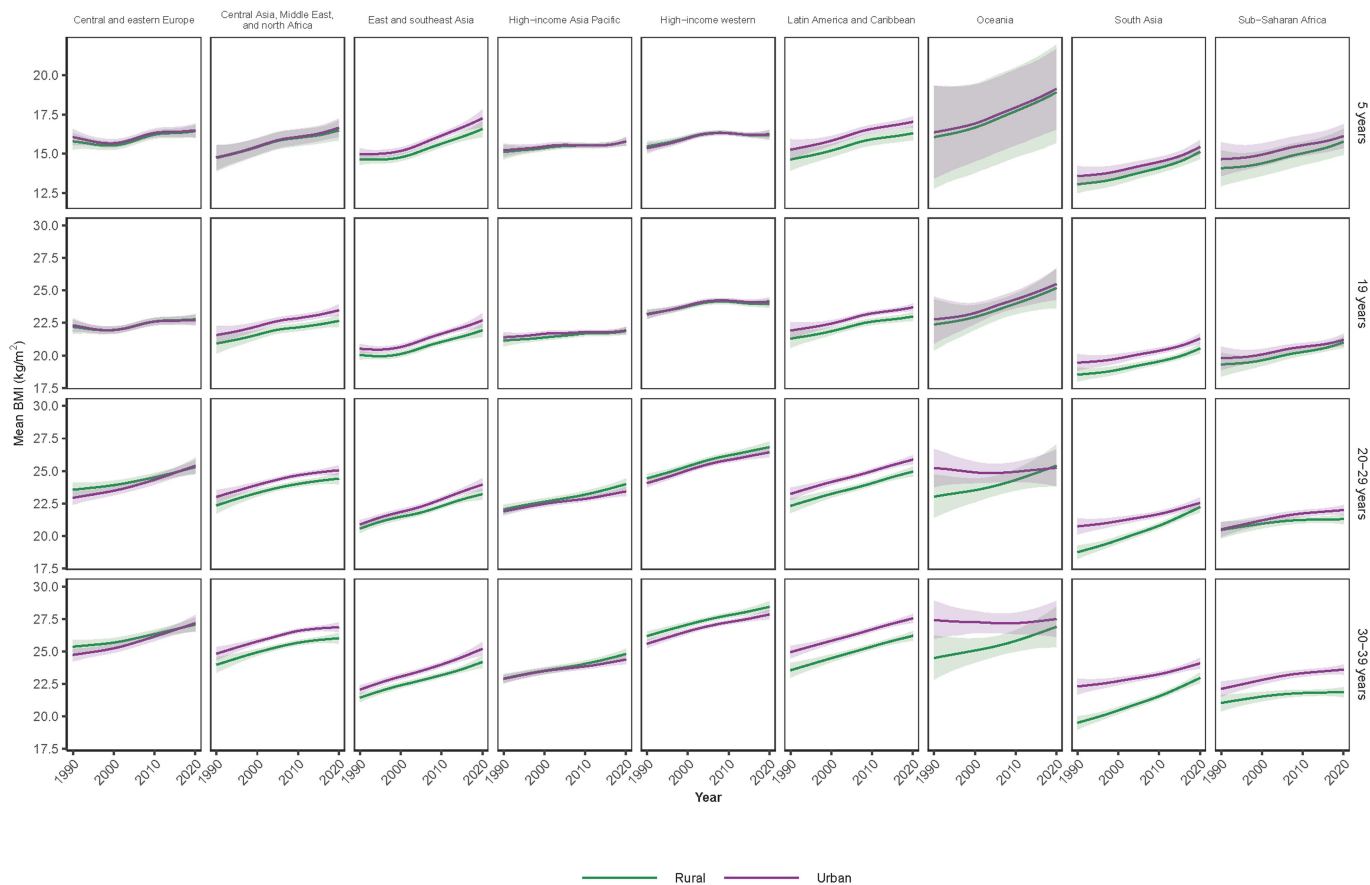
estimate PP for change in mean rural BMI in countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or change in mean urban BMI in countries classified as entirely rural (Tokelau), as indicated in grey.



Extended Data Fig. 6 | Trends in body-mass index (BMI) by place of residence for children, adolescents and young adults for females. The figure shows trends in mean BMI at ages five and 19 years, and in age-standardised mean BMI for young adults (20–29 years and 30–39 years) for females. Shaded areas show

the 95% CIs. Trend for young adults were estimated using a model similar to the one described in Methods, where BMI-age patterns were allowed to vary flexibly via a cubic spline function without knots.

Males

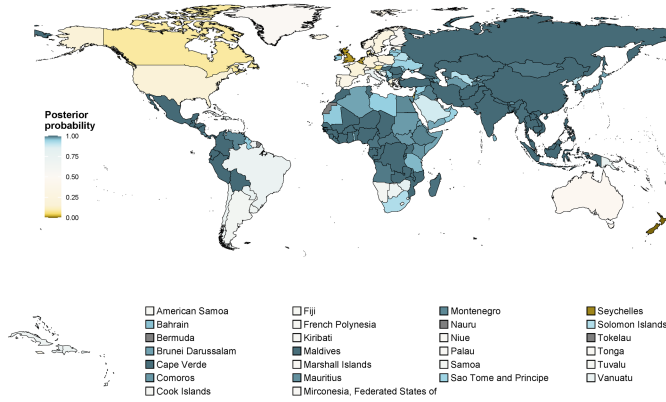


Extended Data Fig. 7 | Trends in body-mass index (BMI) by place of residence for children, adolescents and young adults for males. The figure shows trends in mean BMI at ages five and 19 years, and in age-standardised mean BMI

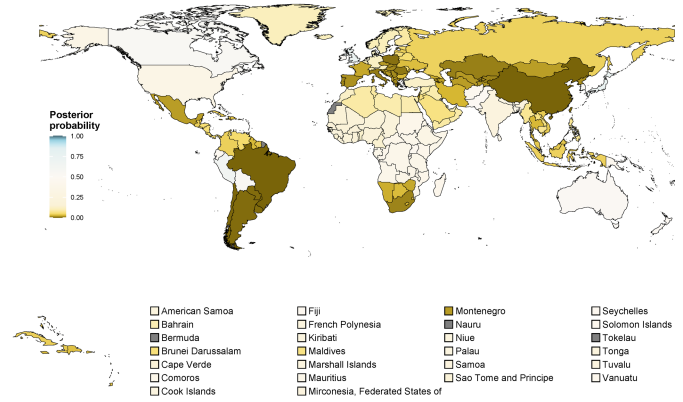
for young adults (20–29 years and 30–39 years) for males. See Extended Data Fig. 6 caption for description of figure contents.

Girls

2020

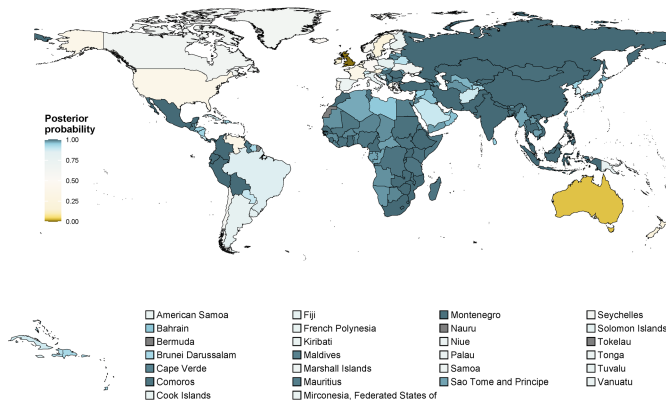


Change from 1990 to 2020

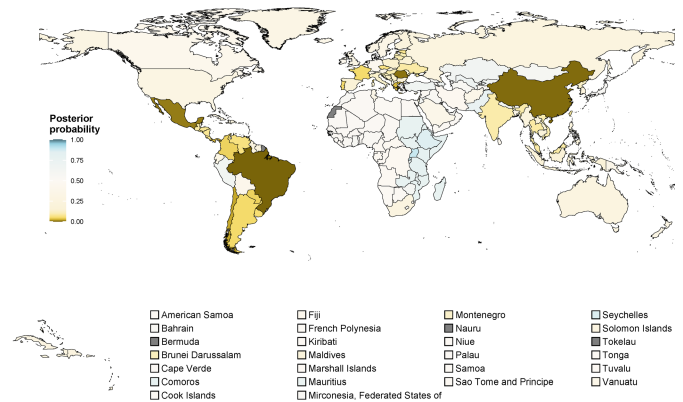


Boys

2020



Change from 1990 to 2020

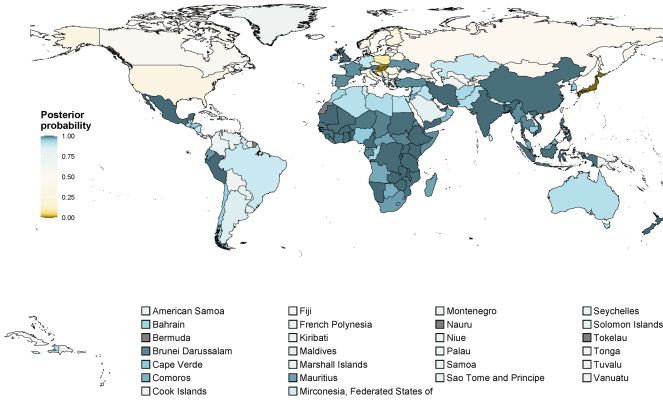


Extended Data Fig. 8 | Posterior probability of urban-rural height difference in 2020 and its increase from 1990 to 2020. The maps show the posterior probability (PP) that age-standardised mean height in 2020 in urban areas was higher than in rural areas (left-hand panels), and the PP that the urban-rural difference in age-standardised mean height increased from 1990 to 2020 (right-hand panels). For 2020, if estimated age-standardised mean urban height is statistically indistinguishable from rural height, the PP is 0.50. PPs closer to 0.50 indicate more uncertainty, those towards 1 indicate more certainty of

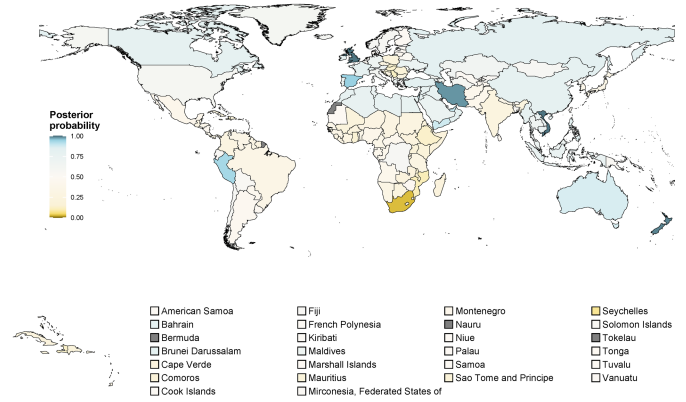
urban children being taller, and those towards 0 indicate more certainty of rural being taller. For change, if an increase in urban-rural difference in mean height is statistically indistinguishable from a decrease, the PP is 0.50. PPs closer to 0.50 indicate more uncertainty, those towards 1 indicate more certainty of an increase in the urban-rural height difference, and those towards 0 indicate more certainty of a decrease. We did not estimate the PP for differences between rural and urban height for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau), as indicated in grey.

Girls

2020

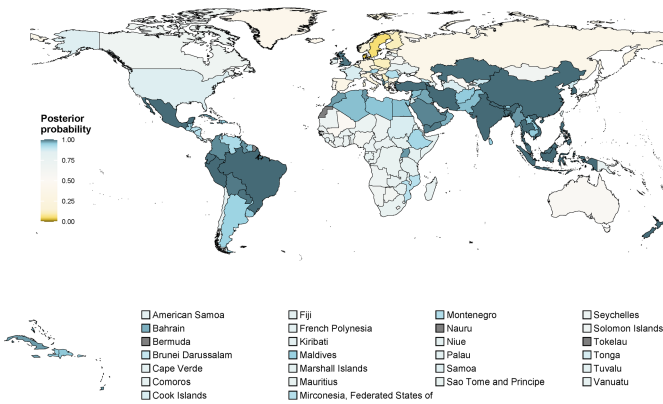


Change from 1990 to 2020

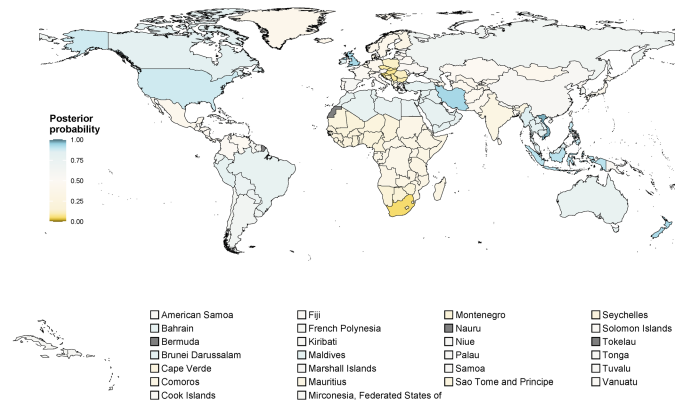


Boys

2020



Change from 1990 to 2020



Extended Data Fig. 9 | Posterior probability of urban-rural body-mass index (BMI) difference in 2020 and its increase from 1990 to 2020. The maps show the posterior probability (PP) that age-standardised mean BMI in 2020 in urban areas was higher than in rural areas (left-hand panels), and the PP that the

urban-rural difference in mean BMI increased from 1990 to 2020 (right-hand panels). We did not estimate the PP for differences between rural and urban BMI for countries classified as entirely urban (Bermuda, Kuwait, Nauru and Singapore) or entirely rural (Tokelau), as indicated in grey.

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

- | n/a | Confirmed |
|-------------------------------------|--|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> The statistical test(s) used AND whether they are one- or two-sided
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A description of all covariates tested |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> For null hypothesis testing, the test statistic (e.g. F , t , r) with confidence intervals, effect sizes, degrees of freedom and P value noted
<i>Give P values as exact values whenever suitable.</i> |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Estimates of effect sizes (e.g. Cohen's d , Pearson's r), indicating how they were calculated |

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection

Data analysis

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

This is a data-pooling study that brings together 2,325 disparate data sources and uses a Bayesian hierarchical model to estimate population risk factor trends. Estimates of mean BMI and height by country, year, sex and place of residence (urban and rural) will be available from www.ncdrisc.org in machine-readable numerical format and as visualisations upon publication of the paper. Input data from publicly available sources can also be downloaded from www.ncdrisc.org and

Human research participants

Policy information about [studies involving human research participants and Sex and Gender in Research](#).

Reporting on sex and gender	NA
Population characteristics	NA
Recruitment	NA
Ethics oversight	NA

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

Life sciences Behavioural & social sciences Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	We pooled and re-analysed population-based quantitative data that had measured height and weight for children and adolescents to estimate trends in mean BMI and height from 1990 to 2020 for 200 countries and territories, using a Bayesian hierarchical model.
Research sample	We used 2,325 population-based studies that had measured height and weight in 71 million participants in 194 countries. Studies were representative of a national, subnational or community population. We used all available and accessible data which met the criteria described below.
Sampling strategy	This is a data pooling study which used all available and accessible data. These are population-based studies, each with sample size set to detect measure of interest in that study. These were pooled in a meta regression which provides more confidence in results by borrowing strength across studies. We included data collected using a probabilistic sampling method with a defined sampling frame. We therefore included studies with simple random and complex survey designs but excluded convenience samples.
Data collection	We used 2,325 population-based studies that had measured height and weight in 71 million participants in 194 countries. We used data on measured height and weight to calculate mean BMI and height by sex and one-year age group. We excluded self-reported data.
Timing	For BMI, we pooled data collected from 1990 to 2020. For Height, we pooled data on those born from 1971 to 2015, after they had reached five years of age – i.e., data collected from 1976 to 2020. For BMI, we included national studies for the 3 years prior to start year, assigning them to the start year, so that they can inform the estimates in countries with slightly earlier national data. We used all available data within these years which met the criteria described below.
Data exclusions	<p>We excluded all data sources that were solely based on self-reported weight and height without a measurement component because these data are subject to biases that vary by geography, time, age, sex and socioeconomic characteristics. We also excluded data sources on population subgroups whose anthropometric status may differ systematically from the general population, including:</p> <ul style="list-style-type: none">• studies that had included or excluded people based on their health status or cardiovascular risk;• studies whose participants were only ethnic minorities;• specific educational, occupational, or socioeconomic subgroups, with the exception noted below;• those recruited through health facilities, with the exception noted below; and• women aged 15-19 years in surveys which sampled only ever-married women or measured height and weight only among mothers. <p>We used school-based data in countries and age-sex groups with school enrolment of 70% or higher. We used data whose sampling frame was health insurance schemes in countries where at least 80% of the population were insured. Finally, we used data collected through general practice and primary care systems in high-income and central European countries with universal insurance, because contact with the primary care systems tends to be as good as or better than response rates for population-based surveys.</p>
Non-participation	This was a secondary data analysis thus no participants were included in this study.
Randomization	Our study is an analysis of trends, and we did not carry out randomised experiments.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

- | n/a | Involvement in the study |
|-------------------------------------|--|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Antibodies |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Eukaryotic cell lines |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Palaeontology and archaeology |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Animals and other organisms |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Clinical data |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Dual use research of concern |

Methods

- | n/a | Involvement in the study |
|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> ChIP-seq |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Flow cytometry |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> MRI-based neuroimaging |