

Rising rural body-mass index is the main driver of the global obesity epidemic in adults

NCD Risk Factor Collaboration (NCD-RisC)*

Body-mass index (BMI) has increased steadily in most countries in parallel with a rise in the proportion of the population who live in cities^{1,2}. This has led to a widely reported view that urbanization is one of the most important drivers of the global rise in obesity^{3–6}. Here we use 2,009 population-based studies, with measurements of height and weight in more than 112 million adults, to report national, regional and global trends in mean BMI segregated by place of residence (a rural or urban area) from 1985 to 2017. We show that, contrary to the dominant paradigm, more than 55% of the global rise in mean BMI from 1985 to 2017—and more than 60% in some low- and middle-income regions—was due to increases in BMI in rural areas. This large contribution stems from the fact that, with the exception of women in sub-Saharan Africa, BMI is increasing at the same rate or faster in rural areas than in cities in low- and middle-income regions. These trends have in turn resulted in a closing—and in some countries reversal—of the gap in BMI between urban and rural areas in low- and middle-income countries, specially for women. In high-income and industrialized countries, we noted a persistently higher rural BMI, especially for women. There is an urgent need for an integrated approach to rural nutrition that enhances financial and physical access to healthy foods, to avoid replacing the rural undernutrition disadvantage in poor countries with a more general malnutrition disadvantage that entails excessive consumption of low-quality calories.

Being underweight or overweight can lead to adverse health outcomes. BMI—a measure of underweight and overweight—is rising in most countries⁴. It is commonly stated that urbanization is one of the most important drivers of the worldwide rise in BMI because diet and lifestyle in cities lead to adiposity^{3–6}. However, such statements are typically based on cross-sectional comparisons in one or a small number of countries. Only a few studies have analysed how BMI is changing over time in rural and urban areas. The majority have been in one country,

over short durations, and/or in one sex and narrow age groups. The few studies that covered more than one country^{7–12} used at most a few dozen data sources and hence could not systematically estimate trends, and focused primarily on women of child-bearing age.

Data on how BMI in rural and urban populations is changing are needed to plan interventions that address underweight and overweight. Here, we report on mean BMI in rural and urban areas of 200 countries and territories from 1985 to 2017. We used 2,009 population-based studies of human anthropometry conducted in 190 countries (Extended Data Fig. 1), with measurements of height and weight in more than 112 million adults aged 18 years and older. We excluded data based on self-reported height and weight because they are subject to bias. For each sex, we used a Bayesian hierarchical model to estimate mean BMI by year, country and rural or urban place of residence. As described in the Methods, the estimated trends in population mean BMI represent a combination of (1) the change in the health of individuals due to change in their economic status and environment, and (2) the change in the composition of individuals that make up the population (and their economic status and environment).

From 1985 to 2017, the proportion of the world's population who lived in urban areas¹ increased from 41% to 55%. Over the same period, global age-standardized mean BMI increased from 22.6 kg m⁻² (95% credible interval 22.4–22.9) to 24.7 kg m⁻² (24.5–24.9) in women, and from 22.2 kg m⁻² (22.0–22.4) to 24.4 kg m⁻² (24.2–24.5) in men. The increase in mean BMI was 2.09 kg m⁻² (1.73–2.44) and 2.10 kg m⁻² (1.79–2.41) among rural women and men, respectively, compared to 1.35 kg m⁻² (1.05–1.65) and 1.59 kg m⁻² (1.33–1.84) in urban women and men. Nationally, change in mean BMI ranged from small decreases among women in 12 countries in Europe and Asia Pacific, to a rise of >5 kg m⁻² among women in Egypt and Honduras. The lowest observed sex-specific mean BMI over these 33 years was that of rural women in Bangladesh of 17.7 kg m⁻² (16.3–19.2) and rural men in

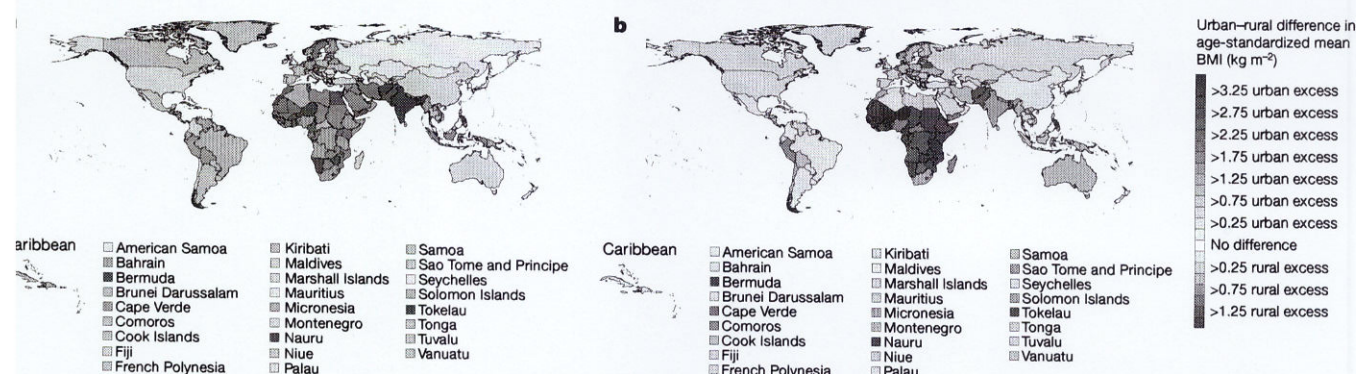


Fig. 1 | The difference between rural and urban age-standardized mean BMI in women. a, Difference in age-standardized mean BMI in 1985.

b, Difference in age-standardized mean BMI in 2017. We did not estimate the difference between rural and urban areas for countries and territories in which the entire population live in areas classified as urban (Singapore,

Hong Kong, Bermuda and Nauru) or rural (Tokelau)—shown in grey. See Extended Data Fig. 2 for mean BMI at the national level and in rural and urban populations in 1985 and 2017. See Extended Data Fig. 6 for comparisons of the results between women and men.

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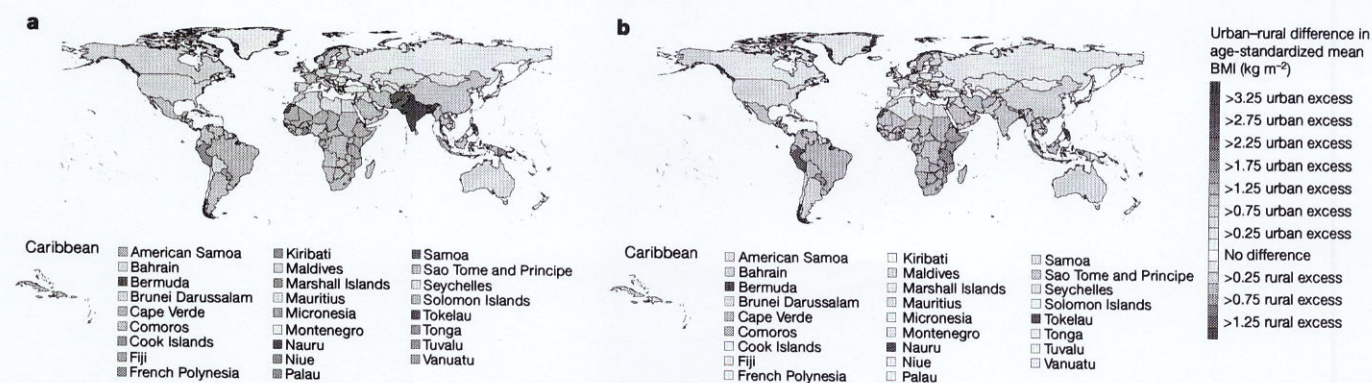


Fig. 2 | The difference between rural and urban age-standardized mean BMI in men. a, Difference in age-standardized mean BMI in 1985. **b**, Difference in age-standardized mean BMI in 2017. We did not estimate the difference between rural and urban areas for countries and territories in which the entire population live in areas classified as urban (Singapore,

Hong Kong, Bermuda and Nauru) or rural (Tokelau)—shown in grey. See Extended Data Fig. 3 for mean BMI at the national level and in rural and urban populations in 1985 and 2017. See Extended Data Fig. 6 for comparison of results between women and men.

Ethiopia of 18.4 kg m^{-2} ($17.0\text{--}19.9$), both in 1985; the highest were 35.4 kg m^{-2} ($33.7\text{--}37.1$) for urban women and 34.6 kg m^{-2} ($33.1\text{--}35.9$) for rural men in American Samoa in 2017 (Extended Data Figs. 2, 3), representing a twofold difference.

In 1985, urban men and women in every country in east, south and southeast Asia, Oceania, Latin America and the Caribbean and a region that comprises central Asia, the Middle East and north Africa had a higher mean BMI than their rural peers (Figs. 1, 2). The urban-rural

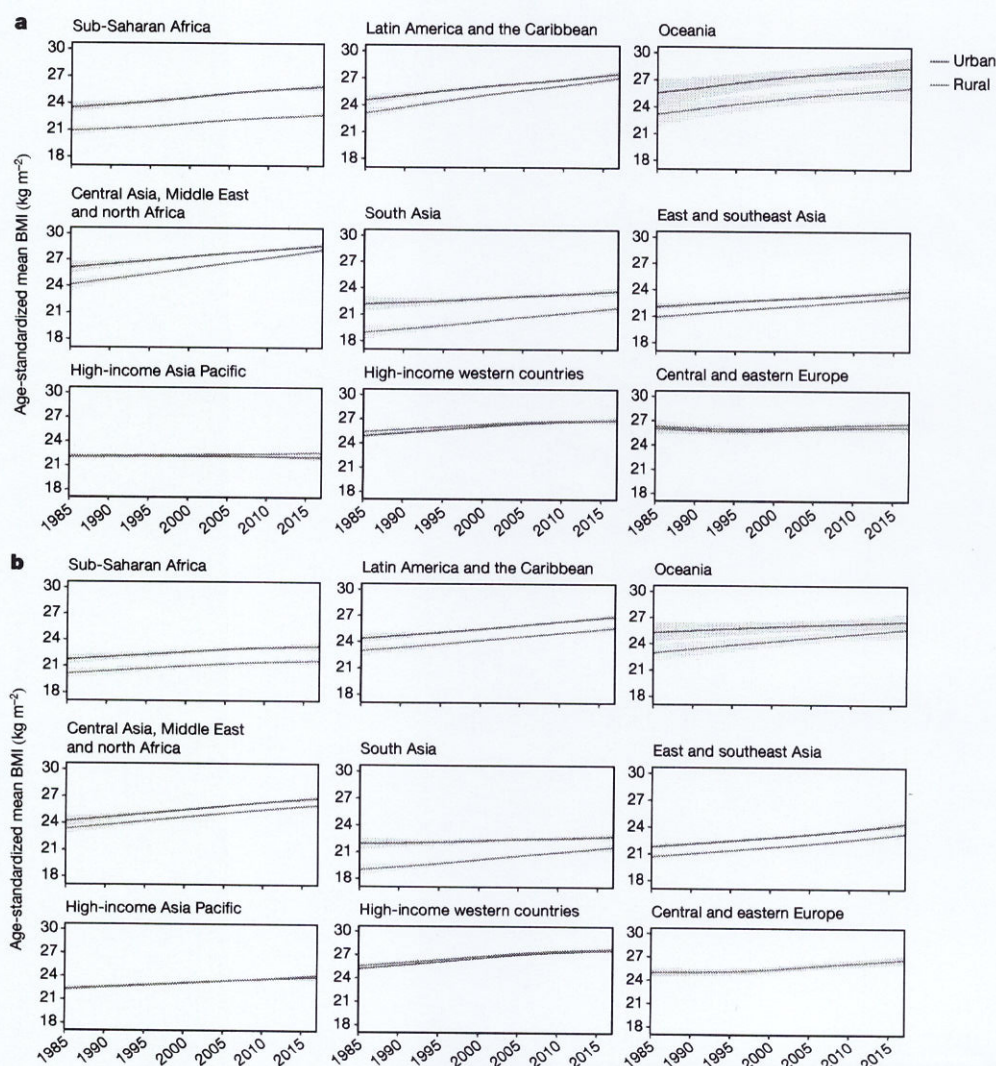


Fig. 3 | Trends in age-standardized mean BMI by rural and urban place of residence. a, Trends are shown for women in each region. **b**, Trends are shown for men in each region. The lines show the posterior mean estimates and the shaded areas show the 95% credible intervals.

Table 1 | Contributors to the rise in mean BMI from 1985 to 2017

		Rural component		Urban component		Urbanization component	
		Absolute contribution (kg m ⁻²)	Percentage contribution (%)	Absolute contribution (kg m ⁻²)	Percentage contribution (%)	Absolute contribution (kg m ⁻²)	Percentage contribution (%)
Emerging economies							
Central Asia, Middle East and north Africa	Men	1.30 (0.96–1.64)	48 (41–54)	1.33 (1.02–1.65)	49 (44–54)	0.09 (0.06–0.12)	3 (2–5)
	Women	1.96 (1.57–2.33)	59 (54–64)	1.31 (0.95–1.69)	39 (34–44)	0.06 (0.03–0.09)	2 (1–3)
East and southeast Asia	Men	1.99 (1.62–2.37)	67 (63–71)	0.66 (0.53–0.80)	22 (20–24)	0.33 (0.26–0.39)	11 (9–14)
	Women	1.81 (1.36–2.26)	73 (67–80)	0.47 (0.32–0.64)	19 (16–22)	0.18 (0.10–0.26)	7 (4–11)
Latin America and the Caribbean	Men	0.86 (0.63–1.09)	31 (26–37)	1.73 (1.31–2.16)	63 (58–67)	0.17 (0.13–0.20)	6 (5–8)
	Women	1.29 (1.07–1.51)	38 (34–43)	2.01 (1.56–2.49)	60 (55–63)	0.06 (0.03–0.10)	2 (1–3)
Oceania	Men	2.24 (1.12–3.37)	90 (80–102)	0.24 (–0.03–0.51)	10 (–2–20)	0.00 (0.00–0.00)	0 (0–0)
	Women	2.41 (0.89–3.98)	81 (69–90)	0.53 (0.18–0.89)	19 (10–31)	0.00 (0.00–0.00)	0 (0–0)
South Asia	Men	1.99 (1.42–2.54)	86 (79–94)	0.20 (0.00–0.40)	8 (0–15)	0.12 (0.09–0.15)	5 (3–8)
	Women	2.18 (1.46–2.87)	80 (73–87)	0.36 (0.13–0.60)	13 (6–19)	0.19 (0.16–0.23)	7 (5–11)
Sub-Saharan Africa							
Sub-Saharan Africa	Men	1.14 (0.64–1.63)	64 (53–73)	0.39 (0.22–0.55)	22 (15–28)	0.23 (0.19–0.27)	14 (10–21)
	Women	1.37 (0.90–1.83)	57 (49–63)	0.58 (0.42–0.74)	24 (21–28)	0.45 (0.42–0.49)	19 (15–25)
High-income and other industrialized regions							
Central and eastern Europe	Men	0.59 (0.35–0.82)	35 (26–44)	1.10 (0.70–1.50)	65 (57–73)	0.00 (–0.01–0.01)	0 (–1–1)
	Women	0.14 (–0.19–0.45)	NR	0.13 (–0.45–0.69)	NR	–0.02 (–0.03–0.00)	NR
High-income Asia Pacific	Men	0.48 (0.37–0.59)	31 (25–37)	1.15 (0.84–1.46)	72 (68–75)	–0.04 (–0.08–0.00)	–2 (–6–0)
	Women	0.12 (–0.01–0.27)	NR	–0.02 (–0.38–0.36)	NR	–0.10 (–0.15 to –0.06)	NR
High-income western countries	Men	0.58 (0.47–0.69)	24 (22–27)	1.80 (1.53–2.07)	76 (74–78)	–0.01 (–0.02–0.00)	0 (–1–0)
	Women	0.39 (0.24–0.54)	21 (15–26)	1.44 (1.09–1.79)	79 (74–84)	0.00 (–0.02–0.01)	0 (–1–1)
World							
World	Men	1.24 (1.06–1.43)	57 (53–60)	0.65 (0.54–0.75)	30 (27–32)	0.30 (0.28–0.32)	14 (12–16)
	Women	1.22 (1.01–1.43)	60 (56–64)	0.56 (0.44–0.69)	28 (24–31)	0.25 (0.23–0.27)	13 (11–15)

Contributions of the rise in mean BMI in rural and urban populations and of urbanization to the rise in mean BMI from 1985 to 2017, by region. Urbanization is defined as an increase in the proportion of the population who live in urban areas. Percentage contributions were calculated as described in the Methods. The reported values are the means and 95% credible intervals. The three percentages sum to 100%. When one component causes an increase in BMI in a region and another does the opposite, the components can be negative or greater than 100%. Urban and rural mean BMI and the percentage of the population who live in urban areas in 1985 and 2017 for each region are provided in Extended Data Table 1. NR, percentage contribution was not reported, because the regional change in mean BMI (which appears in the denominator of the percentage contribution) was small (<0.5 kg m⁻²), leading to unstable estimates.

ap was as large as 3.25 kg m⁻² (2.57–3.96) in women and 3.05 kg m⁻² (2.44–3.68) in men in India. Over time, the BMI gap between rural and urban women shrank in all of these regions by at least 40%, as BMI rose faster in rural areas than in cities (Fig. 3). In 14 countries in these regions, including Armenia, Chile, Jamaica, Jordan, Malaysia, Taiwan and Turkey, the ordering of rural and urban female BMI reversed over time and rural women had higher BMI than their urban peers in 2017 (Fig. 1 and Extended Data Fig. 4).

The mean BMI of rural men also increased more than the mean BMI of urban men in south Asia and Oceania, shrinking the urban–rural BMI gap by more than half (Figs. 2, 3). In east and southeast Asia, Latin America and the Caribbean, and central Asia, the Middle East and north Africa, men in both rural and urban areas experienced a similar BMI increase and, therefore, the urban excess BMI did not change substantially over time.

In contrast to emerging economies, excess BMI among urban women became larger in sub-Saharan Africa (Fig. 3): from 2.59 kg m⁻² (2.21–2.98) in 1985 to 3.17 kg m⁻² (2.93–3.42) in 2017 (posterior probability of the observed increase being a true increase >0.999). This occurred because female BMI rose faster in cities than in rural areas in sub-Saharan Africa. This led to women in sub-Saharan African countries, especially those in west Africa, having the largest urban excess BMI of any country in 2017—for example, more than 3.35 kg m⁻² in Niger, Burkina Faso, Togo and Ghana (Fig. 1 and Extended Data Fig. 4). BMI increased at a similar rate in rural and urban men in sub-Saharan Africa, with the difference in 2017 (1.66 kg m⁻²; 1.37–1.94) being similar to 1985 (1.60 kg m⁻²; 1.13–2.07) (Fig. 2 and Extended Data Fig. 4).

BMI was previously lower in rural areas of low- and middle-income countries than in cities, both because rural residents had higher energy expenditure in their daily work—especially agriculture—and domestic activities, such as fuelwood and water collection^{13,14}, and because lower incomes in rural areas restricted food consumption¹⁵. In middle-income countries, agriculture is increasingly mechanized, cars are used for rural transport as income increases and road infrastructure improves, service and administrative jobs have become more common in rural areas, and some household tasks are no longer needed—for example, because homes have a water connection and use commercial fuels¹⁶. Furthermore, higher incomes as a result of economic growth allow more spending on food and hence higher caloric intake, disproportionately more in rural areas, where a substantial share of income was previously spent on food. Additionally, the consumption of processed carbohydrates may have increased disproportionately in rural areas where such foods have become more readily available through national and transnational companies^{9,17–21}. These changes, referred to as ‘urbanization of rural life’ by some researchers⁶, have contributed to a larger increase in rural BMI^{22,23}.

In contrast to other regions, urbanization in sub-Saharan Africa preceded significant economic growth²⁴. Subsistence farming remains common in Africa, and agriculture remains mostly manual; fuelwood—usually collected by women—is still the dominant fuel in rural Africa; and the use of cars for transportation is limited by poor infrastructure and poverty. In African cities, many people have service and office jobs, and mobility has become less energy-intensive owing to shorter travel distances and the use of cars and buses. Furthermore, urban markets where fresh produce is sold are increasingly replaced by commercially prepared and processed

foods from transnational and local industries and street vendors^{25–27}. These effects are exacerbated by limited time and space for cooking healthy meals and possibly perceptions of large weight as a sign of affluence^{28,29}.

In contrast to low- and middle-income regions, urban women in high-income western and Asia Pacific regions, and in central and eastern Europe, had slightly lower mean BMI than their rural peers in 2017 (Fig. 3). The rural excess BMI for women in these regions changed little from 1985 to 2017. Nationally, the excess BMI of rural women was largest in central and eastern European countries (for example, around 1 kg m⁻² or more in Belarus, Latvia and Czech Republic; Fig. 1 and Extended Data Fig. 4). Rural men in high-income western countries also had an excess BMI compared to urban men throughout the analysis period. The largest rural excess BMI for men in 2017 was seen in Sweden, Czech Republic, Ireland, Australia, Austria and the United States, which all had an excess BMI of 0.35 kg m⁻² or larger. In the high-income Asia Pacific region and in central and eastern Europe, rural and urban men had almost identical BMI throughout these three decades (Fig. 2 and Extended Data Fig. 4).

The lower urban BMI in high-income and industrialized countries reflects a growing rural economic and social disadvantage, including lower education and income, lower availability and higher price of healthy and fresh foods^{30,31}, less access to, and use of, public transport and walking than in cities^{32,33}, and limited availability of facilities for sports and recreational activity³⁴, which account for a significant share of overall physical activity in high-income and industrialized countries.

We also estimated how much of the overall rise in mean BMI since 1985 has been due to increases in BMI of rural and urban populations versus those attributable to urbanization (defined as an increase in the proportion of the population who live in urban areas), in each region and in the world as a whole. At the global level, 60% (56–64) of the rise in mean BMI from 1985 to 2017 in women and 57% (53–60) in men was due to increases in the BMI of rural populations; 28% (24–31) in women and 30% (27–32) in men due to the rise in BMI in urban populations; and 13% (11–15) and 14% (12–16) due to urbanization (Table 1). The contribution of the rise in rural BMI ranged from around 60% to 90% in the mostly rural regions of sub-Saharan Africa, east, south and south-east Asia and Oceania. The contribution of urbanization was small in all regions of the world, with maximum values of 19% (15–25) among women and 14% (10–21) among men in sub-Saharan Africa.

Our results show that, contrary to the prevailing view^{3–6}, BMI is rising at the same rate or faster in rural areas compared to cities, particularly in low- and middle-income countries except among women in sub-Saharan Africa. These trends have resulted in a rural–urban convergence in BMI in most low- and middle-income countries, especially for women. This convergence mirrors the experience of high-income and industrialized countries, where we found a persistently higher BMI in rural areas. The rising rural BMI is the largest contributor to the BMI rise in low- and middle-income regions and in the world as a whole over the last 33 years, which challenges the current paradigm of urban living and urbanization as the key driver of the global epidemic of obesity.

In poor societies, urban areas historically had lower levels of undernutrition^{35,36}, possibly because infrastructure such as roads and electricity facilitate food trade, transport and storage in cities, which can in turn reduce the impacts of agricultural shocks and seasonality. As economic growth and rural nutrition programmes reduce rural caloric deficiency, the rural undernutrition disadvantage may be replaced with a more general and complex malnutrition that entails excessive consumption of low-quality calories. To avoid such an unhealthy transition, the fragmented national and international responses to undernutrition and obesity should be integrated, and the narrow focus of international aid on undernutrition should be broadened, to enhance access to healthier foods in poor rural and urban communities.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, statements of data availability and associated accession codes are available at <https://doi.org/10.1038/s41586-019-1171-x>.

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data; analysed pooled data; and prepared results. M.E. and H.B. wrote the first draft of the manuscript with input from the other authors.

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Additional information

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NCD Risk Factor Collaboration (NCD-RisC)

- Honor Bixby¹, James Benthams², Bin Zhou¹, Mariachiara Di Cesare³, Christopher J. Paciorek⁴, James E. Bennett¹, Cristina Taddei¹, Gretchen A. Stevens⁵, Andrea Rodriguez-Martinez¹, Rodrigo M. Carrillo-Larco¹, Young-Ho Khang⁶, Maroje Sorić⁷, Edward W. Gregg⁸, J. Jaime Miranda⁹, Zulfiqar A. Bhutta^{10,11}, Stefan Savin⁵, Marisa K. Sophiea¹, Maria L. C. Iurilli¹, Bethlehem D. Solomon¹, Melanie J. Cowan⁵, Leanne M. Riley⁵, Goodarz Danaei¹², Pascal Bovet^{13,14}, Adela Chirita-Emandi¹⁵, Ian R. Hambleton¹⁶, Alison J. Hayes¹⁷, Nayu Ikeda¹⁸, Andre P. Kengne¹⁹, Avula Laxmaiah²⁰, Yanping Li²¹, Stephen T. McGarvey²¹, Aya Mostafa²², Martin Neovius²³, Gregor Starc²⁴, Ahmad A. Zainuddin²⁵, Leandro Abarca-Gómez²⁶, Ziad A. Abdeen²⁷, Shynar Abdrakhmanova²⁸, Suhaila Abdul Ghaffar²⁹, Zargar Abdul Hamid²⁹, Jamila Abubakar Garba³⁰, Niveen M. Abu-Rmeileh³¹, Benjamin Acosta-Cazares³², Robert J. Adams³³, Wichai Aekplakorn³⁴, Kaosar Afsana³⁵, Imelda A. Agdeppa³⁶, Carlos A. Aguilar-Salinas³⁷, Charles Aggumang³⁸, Mohamad Hasnan Ahmad²⁵, Noor Ani Ahmad²⁵, Naser Ahmad³⁹, Alireza Ahmadvand⁴⁰, Wolfgang Ahrens⁴¹, Kamel Ajlouni⁴², Fadia AlBuhairan⁴³, Shahla AlDhukair⁴⁴, Hazzaa M. Al-Hazzaa⁴⁵, Mohamed M. Ali⁵, Osman Ali⁴⁶, Ala'a Alkerwi⁴⁷, Amani Rashed Al-Othman⁴⁸, Rajaa Al-Raddadi⁴⁹, Mar Alvarez-Pedrerol⁵⁰, Eman Ali⁵¹, Deepak N. Amarapurkar^{52,576}, Philippe Amouye^{53,54}, Antoinette Amuzu⁵⁵, Lars Bo Andersen⁵⁶, Sigmund A. Andersen⁵⁷, Lars H. Ångquist⁵⁸, Ranjit Mohan Anjana⁵⁹, Alireza Ansari-Moghaddam⁶⁰, Hajer Aounallah-Sikhri⁶¹, Joana Araújo⁶², Inger Ariansen⁶³, Tahir Aris²⁵, Raphael E. Arku⁶⁴, Nimmathota Arappa²⁰, Krishna K. Arya⁶⁵, Thor Aspelund⁶⁶, Felix K. Assah⁶⁷, Maria Cecilia F. Assunção⁶⁸, May Soe Aung⁶⁹, Juha Auvinen⁷⁰, Mária Avdicová⁷¹, Ana Azevedo⁷², Fereidoun Azizi⁷³, Mehrdad Azmin⁴⁰, Bontha V. Babu⁷⁴, Azli Baharudin²⁵, Suhad Bahijiri⁴⁹, Jennifer L. Baker⁷⁵, Nagalla Balakrishna²⁰, Mohamed Bamoshmoosh⁷⁶, Maciej Banach⁷⁷, Piotr Bandoz⁷⁸, José R. Banegas⁷⁹, Carlo M. Barboglio⁸⁰, Alberto Barceló⁸¹, Amina Barkat⁸², Aluisio J. D. Barros⁶⁸, Mauro V. G. Barros⁸³, Iqbal Bata⁸⁴, Anwar M. Batieha⁸⁵, Rosangela L. Batista⁸⁶, Zhamilya Battakova²⁸, Assembekov Batyrbek⁸⁷, Louise A. Baur¹⁷, Robert Beaglehole⁸⁸, Silvia Bel-Serrat⁸⁹, Habiba Ben Romdhane⁹⁰, Judith Benedicks⁹¹, Mikhail Benet⁹², Salim Berkinbayev⁸⁷, Antonio Bernabe-Ortiz⁹, Gailute Bernotiene⁹³, Heloisa Bettio⁹⁴, Aror Bhagyalaxmi⁹⁵, Sumit Bharadwaj⁹⁶, Santosh K. Bhargava⁹⁷, Hongsheng Bi⁹⁸, Yufang Bi⁹⁹, Anna Bieh⁶³, Elysée Claude Bika Lele¹⁰⁰, Mukharram Bikkov¹⁰¹, Bihungum Bista¹⁰², Dusko J. Bjelica¹⁰³, Peter Bjerregaard^{104,105}, Espen Bjertness¹⁰⁶, Marius B. Bjertness¹⁰⁶, Cecilia Björkelund¹⁰⁷, Anneke Blokstra¹⁰⁸, Simona Bo¹⁰⁹, Martin Bobak¹¹⁰, Lynne M. Boddy¹¹¹, Bernhard O. Boehm¹¹², Heiner Boeing¹¹³, Jose G. Boggia¹¹⁴, Carlos P. Boissonnet¹¹⁵, Marialaura Bonaccio¹¹⁶, Vanina Bongard¹¹⁷, Matthias Bopp¹¹⁸, Rossana Borchini¹¹⁹, Herman Borghs¹²⁰, Lien Braeckvelt¹²¹, Lutgart Braeckman¹²², Marjolijn C. E. Bragt¹²³, Imperia Brakjovich¹²⁴, Francesco Branca⁵, Juergen Breckenkamp¹²⁵, João Breda¹²⁶, Hermann Brenner¹²⁷, Lizzy M. Brewster³⁸, Garry R. Brian¹²⁸, Lacramioara Brinduse¹²⁹, Graziella Bruno¹⁰⁹, H. Bas Bueno-de-Mesquita¹⁰⁸, Anna Bugge¹³⁰, Marta Buoncristiano¹²⁶, Genc Burazeri¹³¹, Con Burns¹³², Antonio Cabrera de León¹³³, Joseph Cacciottolo¹³⁴, Hui Cai¹³⁵, Tilema Cama¹³⁶, Christine Cameron¹³⁷, José Camolas¹³⁸, Gamze Can¹³⁹, Günay Can¹⁴⁰, Ana Paula C. Cândido¹⁴¹, Felicia Cañete¹⁴², Mario V. Capanzana³⁶, Eduardo Capuano¹⁴³, Vincenzo Capuano¹⁴³, Viviane C. Cardoso⁹⁴, Axel C. Carlsson¹⁴⁴, Esteban Carmuega¹⁴⁵, Maria J. Carvalho¹⁴⁶, Felipe F. Casanueva¹⁴⁷, Juan-Pablo Casas¹¹⁰, Carmelo A. Caserta¹⁴⁸, Ertugrul Celikcan¹⁴⁹, Laura Censi¹⁵⁰, Juraci A. Cesar¹⁵¹, Snehalatha Chamukuttan¹⁵², Angelique W. Chan¹⁵³, Queenie Chan¹, Himanshu K. Chaturvedi¹⁵⁴, Nishi Chaturvedi¹¹⁰, Norsyamliana Che Abdul Rahim²⁵, Chien-Jen Chen¹⁵⁵, Fangfang Chen¹⁵⁶, Huashuai Chen¹⁵⁷, Shuohua Chen¹⁵⁸, Zhengming Chen¹⁵⁹, Ching-Yu Cheng¹⁵³, Yiling J. Cheng⁸, Angela Chetrit¹⁶⁰, Ekaterina Chikova-Iscener¹⁶¹, Arnaud Chiolerio¹⁶², Shu-Ti Chiou¹⁶³, María-Dolores Chirlaque¹⁶⁴, Belong Cho¹⁶⁵, Yumi Cho¹⁶⁶, Kaare Christensen¹⁰⁵, Diego G. Christofaro¹⁶⁷, Jerzy Chudek¹⁶⁸, Renata Cifkova^{169,170}, Michelle Cilia¹⁷¹, Eliza Cinteza¹⁷², Frank Claessens¹⁷³, Janine Clarke¹⁷⁴, Els Clays¹²², Hans Concijn¹⁷⁵, Susana C. Confortin¹⁷⁶, Cyrus Cooper¹⁷⁷, Tara C. Coppinger¹³², Simona Costanzo¹¹⁶, Dominique Cotte¹⁷⁸, Chris Cowell¹⁷, Cora L. Craig¹³⁷, Amelia C. Crampin¹⁷⁹, Ana B. Crujeiras¹⁸⁰, Juan J. Cruz⁷⁹, Alexandra Cucu¹⁸¹, Liufu Cui¹⁵⁸, Jean Dallongeville¹⁷⁸, Albertino Damasceno¹⁸², Camilla T. Damsgaard⁵⁸, Rachel Dankner¹⁶⁰, Thomas M. Dantoft⁷⁵, Graziella D'Arrigo¹⁸³, Parasmani Dasgupta¹⁸⁴, Saeed Dastgiri¹⁸⁵, Luc Dauchet⁵⁴, Kairat Davletov⁸⁷, Guy De Backer¹²², Dirk De Bacquer¹²², Amalia De Curtis¹¹⁶, Giovanni de Gaetano¹¹⁶, Stefaan De Henauw¹²², Paula Duarte de Oliveira⁶⁸, Karin De Ridder¹⁸⁶, Susanne R. de Rooij¹⁸⁷, Delphine De Smedt¹²², Mohan Deepa⁵⁹, Alexander D. Deev¹⁸⁸, Abbas Dehghan¹⁸⁹, Hélène Delisle¹⁹⁰, Francis Delpuech¹⁹¹, Elaine Dennison¹⁷⁷, Valérie Deschamps¹⁹², Klodian Dhana¹⁸⁹, Meghnath Dhimal¹⁰², Augusto F. Di Castelnuovo¹⁹³, Juvenal Soares Dias-da-Costa¹⁹⁴, Alejandro Diaz¹⁹⁵, Zivka Dika⁷, Shirin Djallalinia¹⁹⁶, Ha T. P. Do¹⁹⁷, Annette J. Dobson¹⁹⁸, Maria Benedetta Donati¹¹⁶, Chiara Donfrancesco¹⁹⁹, Silvana P. Donoso²⁰⁰, Angela Döring²⁰¹, Maria Dorobantu¹⁷², Ahmad Reza Dorosty³⁹, Eleonora d'Orsi¹⁷⁶, Kouamelan Doua²⁰², Wojciech Drygas²⁰³, Jia Li Duan²⁰⁴, Charmaine A. Duante³⁶, Rosemary B. Duda²⁰⁵, Vesselka Duleva¹⁶¹, Virginija Dulskiene⁹³, Samuel C. Dumith¹⁵¹, Vilnis Dzerve²⁰⁶, Elzbieta Dzikowska-Zaborszczyk⁷⁷, Ricky Eddie²⁰⁷, Eruke E. Egbagbe²⁰⁸, Robert Eggertsen¹⁰⁷, Gabriele Eiben²⁰⁹, Ulf Ekelund⁵⁷, Jalila El Ati²¹⁰, Denise Eldemire-Shearer²¹¹, Marie Eliassen⁷⁵, Paul Elliott¹, Reina Engle-Stone²¹², Rajiv T. Erasmus²¹³, Cihangir Erem¹³⁹, Louise Eriksen¹⁰⁵, Johan G. Eriksson²¹⁴, Jorge Escobedo-de la Peña³², Alun Evans²¹⁵, David Faeh¹¹⁸, Caroline H. Fall¹⁷⁷, Victoria Farrugia Sant'Angelo¹⁷¹, Farshad Farzadfar³⁹, Mohammad R. Fattahi²¹⁶, Francisco J. Felix-Redondo²¹⁷, Trevor S. Ferguson²¹¹, Romulo A. Fernandes¹⁶⁷, Daniel Fernández-Bergés²¹⁸, Daniel Ferrante²¹⁹, Marika Ferrari²²⁰, Caterina Ferreccio²²¹, Eldridge Ferrer³⁶, Jean Ferrières¹¹⁷, Anna Fjalkowska²²², Günther Fink^{223,224}, Krista Fischer²²⁵, Eric Monterubio Flores²²⁶, Bernhard Föger¹⁷⁵, Leng Huat Foo²²⁷, Ann-Sofie Forslund²²⁸, Maria Forsner²²⁸, Heba M. Fouad⁵¹, Damian K. Francis²²⁹, Maria do Carmo Franco²³⁰, Oscar H. Franco¹⁸⁹, Guillermo Frontera²³¹, Flavio D. Fuchs²³², Sandra C. Fuchs²³³, Yuki Fujita²³⁴, Takuro Furusawa²³⁵, Zbigniew Gaciong²³⁶, Mihai Gafencu¹⁵, Daniela Galeone²³⁷, Fabio Galvano²³⁸, Jingli Gao¹⁵⁸, Manoli Garcia-de-la-Hera²³⁹, Dickman Gareta²⁴⁰, Sarah P. Garnett¹⁷, Jean-Michel Gaspoz²⁴¹, Magda Gasull²⁴², Louise Gates²⁴³, Andrea Gazzinelli²⁴⁴, Harald Geiger¹⁷⁵, Johanna M. Geleijnse²⁴⁵, Ali Ghanbari³⁹, Erfan Ghasemi³⁹, Anosheh Ghasemian⁴⁰, Oana-Florentina Gheorghe-Fronea¹⁷², Simona Giampaoli¹⁹⁹, Francesco Gianfagna^{246,193}, Tiffany K. Gill²⁴⁷, Jonathan Giovannelli⁵⁴, Glen Gironella³⁶, Aleksander Giwercman²⁴⁸, Justyna Godos²³⁸, Sibel Gogen¹⁴⁹, Rebecca A. Goldsmith²⁴⁹, David Goltzman²⁵⁰, Helen Gonçalves⁵⁸, Angel R. Gonzalez²⁵¹, David A. Gonzalez-Chica²⁴⁷, Marcela Gonzalez-Gross²⁵², Margot González-Leon³², Juan P. González-Rivas²⁵³, María-Elena González-Villalpando²⁵⁴, Frederic Gottrand⁵³, Antonio Pedro Graça²⁵⁵, Sidsel Graff-Iversen⁶³, Dušan Grafnetter²⁵⁶, Aneta Grajda²⁵⁷, Maria G. Grammatikopoulou²⁵⁸, Ronald D. Gregor⁸⁴, Tomasz Grodzicki²⁵⁹, Anders Grantved¹⁰⁵, Giuseppe Grosso²³⁸, Gabriella Gruden¹⁰⁹, Dongfeng Gu²⁶⁰, Emanuela Gualdi-Russo²⁶¹, Elias F. Gudmundsson²⁶², Vilmundur Gudnason⁶⁶, Ramiro Guerrero²⁶³, Idris Guessous²⁴¹, Andre L. Guimaraes²⁶⁴, Martin C. Gulliford²⁶⁵, Johanna Gunnlaugsdottir²⁶², Marc Gunter²⁶⁶, Xiuhua Guo²⁶⁷, Yin Guo²⁶⁷, Prakash C. Gupta²⁶⁸, Rajeev Gupta²⁶⁹, Oye Gureje²⁷⁰, Beata Gurzkowska²⁵⁷, Laura Gutierrez²⁷¹, Felix Gutzwiller¹¹⁸, Farzad Hadaegh⁷³, Charalambos A. Hadjigeorgiou²⁷², Rosa Haghsheenas⁴⁰, Jytte Halkjær²⁷³, Rebecca Hardy¹¹⁰, Rachakula Hari Kumar²⁰, Maria Hassapidou²⁷⁴, Jun Hata²⁷⁵, Teresa Haugsgjerd²⁷⁶, Jiang He²⁷⁷, Yuna He²⁷⁸, Regina Heidinger-Felso²⁷⁹, Mirjam Heinen⁸⁹, Tatjana Hejgaard²⁸⁰, Marleen Elisabeth Hendriks²⁸¹, Ana Henriques⁶², Leticia Hernandez Cadena²²⁶, Sauli Herrala²⁸², Victor M. Herrera²⁸³, Isabella Herter-Aeberli²⁸⁴, Ramin Heshmat²⁸⁵, Allan G. Hill¹⁷⁷, Sai Yin Ho²⁸⁶, Suzanne C. Ho²⁸⁷, Michael Hobbs²⁸⁸, Albert Hofman¹⁸⁹, Wilma M. Hopman²⁸⁹, Andrea R. V. R. Horimoto²⁹⁰, Claudia M. Hormiga²⁹¹, Bernardo L. Horta⁶⁸, Leila Hout²⁹², Christina Howitt¹⁶, Thein Hein Htay²⁹³, Aung Soe Htet²⁹⁴, Maung Maung Than Htike²⁹⁴, Yonghua Hu²⁹⁵, José María Huerta²⁹⁶, Ilpo Tapani Huhtaniemi¹, Constanta Huidumac Petrescu¹⁸¹, Martijn Huisman^{297,298}, Abdullatif Hussein³¹, Chinh Nguyen Huu¹⁹⁷, Inge Huybrechts²⁶⁶, Nahla Hwalla²⁹⁹, Jolanda Hyska¹³¹, Licia Iacoviello^{246,116}, Jesús M. Ibarluzea³⁰⁰, Mohsen M. Ibrahim³⁰¹, Norazizah Ibrahim Wong²⁵, M. Arfan Ikram¹⁸⁹, Vilma E. Irazola²⁷¹, Takafumi Ishida³⁰², Muhammad Islam¹⁰, Aziz al-Safi Ismail²²⁷, Vanja Ivkovic³⁰³, Masanori Iwasaki³⁰⁴, Tuija Jääskeläinen²¹⁴, Rod T. Jackson⁸⁸, Jeremy M. Jacobs³⁰⁵, Hashem Jaddou⁸⁵, Tazeen Jafar¹⁵³, Kenneth James²¹¹, Kazi M. Jamil⁴⁸, Konrad Jamrozik^{247,576}, Imre Janszky³⁰⁶, Edward Janus³⁰⁷, Juel Jarani³⁰⁸, Marjo-Riitta Jarvelin^{70,1}, Grazyna Jasienska²⁵⁹, Ana Jelakovic³⁰³, Bojan Jelakovic³⁰⁹, Garry Jennings³¹⁰, Seung-Iyeal Jeong³¹¹, Chao Qiang Jiang³¹², Ramon O. Jimenez³¹³, Michel Joffres³¹⁴, Mattias Johansson²⁶⁶, Jari J. Jokelainen²⁸², Jost B. Jonas³¹⁵, Torben Jørgensen⁷⁵, Pradeep Joshi³¹⁶, Dragana P. Jovic³¹⁷, Jacek Józwiak³¹⁸, Anne Juolevi²¹⁴, Gregor Jurak²⁴, Vesna Juresa⁷, Rudolf Kaaks¹²⁷, Anthony Kafatos³¹⁹, Eero O. Kajantie²¹⁴, Ofra Kalter-Leibovici¹⁶⁰, Nor Azmi Kamaruddin³²⁰, Yves Kameli¹⁹¹, Efthymios Kapantais³²¹, Khem B. Karki³²², Amir Kasaeian³⁹, Marzieh Katibeh³²³, Joanne Katz³²⁴, Peter T. Katzmarzyk³²⁵, Jussi Kauhanen³²⁶, Prabhdeep Kaur³²⁷, Maryam Kavousi¹⁸⁹, Gylli Kazakbaeva¹⁰¹, Ulrich Keil³²⁸, Lital Keinan-Boker²⁴⁹, Sirkka Keinänen-Kiukaanniemi²⁸², Roya Kelishadi³²⁹, Cecily Kelleher⁸⁹, Han C. G. Kemper³³⁰, Alina Kerimkulova³³¹, Mathilde Kersting³³², Timothy Key¹⁵⁹, Yousef Saleh Khader⁸⁵, Davood Khalili⁷³

- Mohammad Khateeb⁴², Kay-Tee Khaw³³³, Bahareh Kheiri⁷³, Alireza Khosravi³³⁴, Ilse M. S. L. Khouw¹²³, Stefan Kiechl³³⁵, Ursula Kiechl-Kohlendorfer³³⁵, Japhet Killewo³³⁶, Jeongseon Kim³³⁷, Yeon-Yong Kim³¹¹, Jeannette Klimont³³⁸, Jurate Klumbiene⁹³, Michael Knoflach³³⁵, Bhawesh Koirala³³⁹, Elin Kolle⁵⁷, Patrick Kolsteren¹²², Jürgen König³⁴⁰, Raija Korpelainen^{70,341}, Paul Korrovits³⁴², Magdalena Korzycka²²², Seppo Koskinen²¹⁴, Katsuyasu Kouda³⁴³, Viktoria A. Kovacs³⁴⁴, Sudhir Kowlessur³⁴⁵, Sławomir Koziel³⁴⁶, Wolfgang Kratzer³⁴⁷, Susi Kriemler¹¹⁸, Peter Lund Kristensen¹⁰⁵, Steinar Krokstad³⁰⁶, Daan Kromhout³⁴⁸, Herculina S. Kruger³⁴⁹, Ruzena Kubinova³⁵⁰, Renata Kuciene⁹³, Diana Kuh¹¹⁰, Urho M. Kujala³⁵¹, Enisa Kujundzic³⁵², Zbigniew Kulaga²⁵⁷, R. Krishna Kumar³⁵³, Marie Kunešová³⁵⁴, Paweł Kurjata²⁰³, Yadlapalli S. Kusuma³⁵⁵, Kari Kuulasmaa²¹⁴, Catherine Kyobutungi³⁵⁶, Quang Ngoc La³⁵⁷, Fatima Zahra Laamiri³⁵⁸, Tiina Laatikainen²¹⁴, Carl Lachat¹²², Youcef Laid³⁵⁹, Tai Hing Lam²⁸⁶, Maja Lang Morovic³⁶⁰, Vera Lanska²⁵⁶, Georg Lappas³⁶¹, Bagher Larijani³⁶², Tint Swe Latt³⁶³, Lars E. Laugsand³⁰⁶, Laura Lauria¹⁹⁹, Maria Lazo-Porras⁹, Khanh Le Nguyen Bao¹⁹⁷, Agnès Le Port³⁶⁴, Tuyen D. Le¹⁹⁷, Jeannette Lee³⁶⁵, Jeonghee Lee³³⁷, Paul H. Lee³⁶⁶, Terho Lehtimäki³⁶⁷, Daniel Lemogoum³⁶⁸, Naomi S. Levitt³⁶⁹, Christa L. Lilly³⁷⁰, Mei-Yen Lim³⁶⁵, M. Fernanda Lima-Costa³⁷¹, Hsien-Ho Lin³⁷², Xu Lin³⁷³, Lars Lind³⁷⁴, Allan Linneberg⁷⁵, Lauren Lissner¹⁰⁷, Mieczysław Litwin²⁵⁷, Ling Liu³⁷⁵, Helle-Mai Loit³⁷⁶, Luis Lopes¹⁴⁶, Tania Lopez³⁷⁷, Esther López-García⁷⁹, Roberto Lorbeer³⁷⁸, Paulo A. Lotufo⁹⁴, José Eugenio Lozano³⁷⁹, Dalia Luksiene⁹³, Annamari Lundqvist²¹⁴, Robert Lundqvist³⁸⁰, Nuno Lunet¹⁴⁶, Per Lytsy³⁸¹, Guansheng Ma²⁹⁵, Jun Ma²⁹⁵, George L. L. Machado-Coelho³⁸², Aristides M. Machado-Rodrigues³⁸³, Suka Machi³⁸⁴, Stefania Maggi³⁸⁵, Dianna J. Magliano³⁸⁶, Immanuella Magripilis³⁸⁷, Bernard Maire¹⁹¹, Marijeta Majer⁷, Marcia Makdisse³⁸⁸, Atefeh Malekzadeh²¹⁶, Reza Malekzadeh²¹⁶, Rahul Malhotra¹⁵³, Sofia Malyutina³⁸⁹, Lynell V. Maniego³⁶, Yannis Manios³⁹⁰, Jim I. Mann³⁹¹, Inzo Manzato³⁹², Paula Margozzini²²¹, Anastasia Markaki³⁹³, Donagh Markey³⁹⁴, Eliza Markidou Ioannidou³⁹⁵, Larissa Pruner Marques¹⁷⁶, Pedro Marques-Vidal³⁹⁶, Jaume Marrugat³⁹⁷, Rosemarie Martin³⁹⁸, Yves Martin-Prevel¹⁹¹, Reynaldo Martorel³⁹⁹, Eva Martos⁴⁰⁰, Stefano Marventano²³⁸, Shariq R. Masoodi⁴⁰¹, Ellisiv B. Mathiesen⁴⁰², Prashant Mathur⁴⁰³, Alicia Matijasevich⁹⁴, Tandi E. Matsha⁴⁰⁴, Artur Mazur⁴⁰⁵, Jean Claude N. Mbanya⁶⁷, Shelly R. McFarlane²¹¹, Martin McKee⁵⁵, Itala McLachlan⁴⁰⁶, Rachael M. McLean³⁹¹, Scott B. McLean¹⁷⁴, Freige A. McNulty⁸⁹, Safiah Md Yusof⁴⁰⁷, Sounnia Mediene-Benchekor²⁹², Urate Medzioniene⁹³, Parinaz Mehdipour³⁹, Aline Meirhaeghe⁴⁰⁸, Ørger Meisfjord⁶³, Christa Meisinger²⁰¹, Ana Maria B. Menezes⁶⁸, Jeetha R. Menon⁷⁴, Gert B. M. Mensink⁴⁰⁹, Alibek Mereke⁸⁷, Indrapal I. Meshram²⁰, Andres Metspalu²²⁵, Haakon E. Meyer¹⁰⁶, Jie Mi¹⁵⁶, Kim F. Michaelsen⁵⁸, Nathalie Michels¹²², Kairit Mikkel²²⁵, Jody C. Miller³⁹¹, Ildia S. Minderico⁴¹⁰, Juan Francisco Miquel²²¹, Daphne Mirkopoulou⁴¹¹, Rkin Mirrakhimov³³¹, Marijeta Misigoi-Durakovic⁷, Antonio Mistretta²³⁸, Veronica Mocanu⁴¹², Pietro A. Modesti⁴¹³, Sahar Saeedi Moghaddam³⁹, Aham Mohajer³⁹, Mostafa K. Mohamed²², Kazem Mohammad³⁹, Ioushin Mohammadifard⁴¹⁴, Viswanathan Mohan⁵⁹, Salim Mohanna⁹, Iuhammad Fadhli Mohd Yusoff²⁵, Farnam Mohebi³⁹, Marie Moitry^{415,416}, rude Molbo⁵⁸, Line T. Møllehave⁷⁵, Niels C. Møller¹⁰⁵, Dénes Molnár²⁷⁹, mirabbas Momenan⁷³, Charles K. Mondo⁴¹⁷, Eric A. Monterrubio⁴¹⁸, otsedi Daniel K. Moryeki⁴¹⁹, Jin Soo Moon⁴²⁰, Leila B. Moreira²³³, Iain Morejon⁴²¹, Luis A. Moreno⁴²², Karen Morgan⁴²³, Suzanne Morin²⁵⁰, rik Lykke Mortensen⁵⁸, George Moschonis⁴²⁴, Malgorzata Mossakowska⁴²⁵, orge Mota¹⁴⁶, Anabela Mota-Pinto³⁸³, Mohammed Esmael Mottlagh⁴²⁶, orge Motta⁴²⁷, Kelias P. Msyamboza⁴²⁸, Thet Thet Mu⁴²⁹, Magdalena Muc³⁸³, oban Mugoša³⁵², Maria Lorenza Muiasan⁴³⁰, Parvina Mukhtorova⁴³¹, Iartina Müller-Nurasyid²⁰¹, Neil Murphy²⁶⁶, Jaakko Mursu³²⁶, aine M. Murtagh³⁹⁸, Sanja Music Milanovic^{360,7}, Vera Musil⁷, Iraj Nabipour⁴³², hohreh Naderimaghnam³⁹, Gabriele Nagel⁴³³, Balkish M. Naidu²⁵, arunobu Nakamura⁴³⁴, Jana Námesná⁷¹, Ei Ei K. Nang³⁶⁵, nay B. Nangia⁴³⁵, Martin Nankap⁴³⁶, Sameer Narake²⁶⁸, Paola Nardone¹⁹⁹, atthias Nauck³⁷⁸, Eva Maria Navarrete-Muñoz²³⁹, William A. Neal³⁷⁰, iu Nelis³⁷⁶, Liis Nelis³⁷⁶, Ilona Nenko²⁵⁹, Flavio Nervi²²¹, Chung T. Nguyen⁴³⁷, guyen D. Nguyen⁴³⁸, Quang Ngoc Nguyen⁴³⁹, Ramfis E. Nieto-Martínez⁴⁴⁰, uang Ning⁹⁹, Toshiharu Ninomiya²⁷⁵, Sania Nishtar⁴⁴¹, Marianna Noale³⁸⁵, scar A. Noboa¹¹⁴, Teresa Norat¹, Sawada Norie⁴⁴², Davide Noto⁸⁰, ohannad Al Nsour⁴⁴³, Eha Nori³⁷⁶, Moffat Nyirenda⁵⁵, Galina Obreja⁴⁴⁴, igélica M. Ochoa-Avilés²⁰⁰, Eiji Oda⁴⁴⁵, Kyungwon Oh¹⁶⁶, Kumiko Ohara²³⁴, utaro Ohtsuka⁴⁴⁶, Örn Olafsson²⁶², Maria Teresa Anselmo Olinto⁴⁴⁷, abel O. Oliveira⁶⁸, Maciej Oltarzewski⁴⁴⁸, Mohd Azahadi Omar²⁵, tan Onat¹⁴⁰, Terence W. O'Neill⁴⁴⁹, Sok King Ong⁴⁵⁰, Lariane M. Ono¹⁷⁶, dro Ordunez²⁸¹, Dermot O'Reilly²¹⁵, Rui Ornelas⁴⁵¹, Ana P. Ortiz⁴⁵², dro J. Ortiz², Merete Osler⁴⁵³, Clive Osmond⁴⁵⁴, Sergej M. Ostojic⁴⁵⁵, shin Ostovar³⁹, Johanna A. Otero²⁹¹, Kim Overvad⁴⁵⁶, Ellis Owusu-Dabo⁴⁵⁶, ed Michel Paccaud⁴⁵⁷, Cristina Padez³⁸³, Ioannis Pagkalos²⁷⁴, Elena Pahomova²⁰⁶, Andrzej Pająk²⁵⁹, Domenico Palli⁴⁵⁸, Alberto Palloni⁴⁵⁹, Luigi Palmieri¹⁹⁹, Wen-Harn Pan¹⁵⁵, Songhomitra Panda-Jonas³¹⁵, Arvind Pandey¹⁵⁴, Francesco Panza⁴⁶⁰, Dimitrios Papandreou⁴⁶¹, Soon-Woo Park⁴⁶², Winsome R. Parnell³⁹¹, Mahboubeh Parsaeian³⁹, Ionela M. Pascanu⁴⁶³, Nikhil D. Patel⁴⁶⁴, Ivan Pecin^{309,303}, Mangesh S. Pednekar²⁶⁸, Nasheeta Peer⁴⁶⁵, Sergio Viana Peixoto³⁷¹, Markku Peltonen²¹⁴, Alexandre C. Pereira²⁹⁰, Cynthia M. Pérez⁴⁵², Napoleon Perez-Farinos⁴⁶⁶, Annette Peters²⁰¹, Astrid Petersmann³⁷⁸, Janina Petkeviciene⁹³, Ausra Petrauskienė⁹³, Niloofar Peykari¹⁹⁶, Son Thai Pham⁴⁶⁷, Daniela Pierannunzio¹⁹⁹, Iris Pigeot⁴⁶⁸, Hynek Pikhart¹¹⁰, Aida Pilav⁴⁶⁹, Lorenza Pilotto⁴⁷⁰, Francesco Pistelli⁴⁷¹, Freda Pitakaka⁴⁷², Aleksandra Piwonska²⁰³, Pedro Plans-Rubió⁴⁷³, Bee Koon Poh³²⁰, Hermann Pohlabein⁴⁶⁸, Raluca M. Pop⁴⁶³, Stevo R. Popovic¹⁰³, Miquel Porta⁴⁷⁴, Marileen L. P. Portegies¹⁸⁹, Georg Posch¹⁷⁵, Dimitrios Poulimeneas²⁷⁴, Hamed Pouraram³⁹, Akram Pourshams⁴⁷⁵, Hossein Poustchi⁴⁷⁶, Rajendra Pradeep⁴⁷⁹, Alison J. Price⁵⁵, Jacqueline F. Price⁴⁰⁶, Jardenia J. Puder³⁹⁶, Iveta Pudule⁴⁷⁷, Soile E. Puhakka^{341,70}, Maria Puiu¹⁵, Margus Punab³⁴², Radwan F. Qasrawi²⁷, Mostafa Qorbani⁴⁷⁸, Tran Quoc Bao⁴⁷⁹, Madhavi S. Radhika²⁰, Ivana Radic⁴⁵⁵, Ricardas Radisauskas⁹³, Mahfuzar Rahman⁴⁸⁰, Mahmudur Rahman⁴⁸¹, Olli Raitakari⁴⁸², Manu Raj³⁵³, Hemalatha Rajkumar²⁰, Serali Rakhmatulloev⁴³¹, Sudha Ramachandra Rao³²⁷, Ambady Ramachandran¹⁵², Jacqueline Ramke⁸⁸, Elisabete Ramos⁷², Rafel Ramos⁴⁸³, Lekhray Rampal⁴⁸⁴, Sanjay Rampal⁴⁸⁵, Kodavanti Mallikharjuna Rao²⁰, Ramon A. Rascon-Pacheco³², Mette Rasmussen⁴⁸⁶, Josep Redon⁴⁸⁷, Paul Ferdinand M. Reganit⁴⁸⁸, Valéria Regecová⁴⁸⁹, Luis Revilla³⁷⁷, Lourdes Ribas-Barba⁴⁹⁰, Robespierre Ribeiro⁴⁹¹, Elio Riboli¹, Fernando Rigo⁴⁹², Natascia Rinaldo²⁶¹, Tobias F. Rinke de Wit⁴⁹³, Ana Rito⁴⁹⁴, Raphael M. Ritti-Dias⁴⁹⁵, Juan A. Rivera²²⁶, Cynthia Robitaille⁴⁹⁶, Daniela Rodrigues³⁸³, Fernando Rodríguez-Artalejo⁷⁹, María del Cristo Rodríguez-Pérez⁴⁹⁷, Laura A. Rodríguez-Villamizar⁴⁹⁸, Rosalba Rojas-Martínez⁴¹⁸, Nipa Rojroongwasinkul³⁴, Dora Romaguera¹⁸⁰, Annika Rosengren^{499,107}, Ian Rouse⁵⁰⁰, Joel G. R. Roy¹⁷⁴, Adolfo Rubinstein²⁷¹, Frank J. Rühli¹¹⁸, Jean-Bernard Ruidavets¹¹⁷, Emma Ruiz Moreno⁵⁰¹, Blanca Sandra Ruiz-Betancourt³², Paola Russo⁵⁰², Petra Rust³⁴⁰, Marcin Rutkowski⁷⁸, Charumathi Sabanayagam⁵⁰³, Harshpal S. Sachdev⁵⁰⁴, Saied Safiri⁵⁰⁵, Olfa Saidi⁹⁰, Benoit Salanave¹⁹², Eduardo Salazar-Martínez²²⁶, Diego Salmerón²⁹⁶, Veikko Salomaa²¹⁴, Jukka T. Salonen⁵⁰⁶, Massimo Salvetti⁴³⁰, Jose Sánchez-Abanto⁵⁰⁷, Sandjaja⁵⁰⁸, Susana Sans⁵⁰⁹, Loreto Santa-Marina⁵¹⁰, Diana A. Santos⁵¹¹, Ina S. Santos⁶⁸, Osvaldo Santos⁵¹¹, Rute Santos¹⁴⁶, Sara Santos Sanz⁴⁶⁶, Jouko L. Saramies⁵¹², Luis B. Sardinha⁵¹¹, Nizal Sarrafzadegan⁵¹³, Kai-Uwe Saum¹²⁷, Savvas Savva²⁷², Mathilde Savy¹⁹¹, Marcia Scazufca⁵¹⁴, Angelika Schaffrath Rosario⁴⁰⁹, Herman Schargrodsky⁵¹⁵, Anja Schienkiewitz⁴⁰⁹, Karin Schindler⁵¹⁶, Sabine Schipf³⁷⁸, Carsten O. Schmidt³⁷⁸, Ida Maria Schmidt⁵¹⁷, Ben Schöttker¹²⁷, Constance Schultz¹⁸⁷, Aletta E. Schutte^{349,19}, Sylvain Sebert⁷⁰, Aye Aye Sein²⁹⁴, Rusidah Selamat²⁵, Vedrana Sember²⁴, Abhijit Sen³⁰⁶, Idowu O. Senbanjo⁵¹⁸, Sadaf G. Sepanlou³⁹, Victor Sequera¹⁴², Luis Serra-Majem⁵¹⁹, Jennifer Servais¹⁷⁴, Svetlana A. Shalnova¹⁸⁸, Sanjib K. Sharma³³⁹, Jonathan E. Shaw³⁸⁶, Lela Shengelia⁵²⁰, Kenji Shibuya³⁰², Hana Shimizu-Furusawa⁵²¹, Dong Wook Shin⁵²², Youchan Shin⁵⁰³, Alfonso Siani⁵⁰², Rosalynn Siantar⁵⁰³, Abila M. Sibai²⁹⁹, Antonio M. Silva⁸⁶, Diego Augusto Santos Silva¹⁷⁶, Mary Simon¹⁵², Judith Simons⁵²³, Leon A. Simons⁵²⁴, Khairil Si-Ramlee⁴⁵⁰, Agneta Sjöberg¹⁰⁷, Michael Sjöström²³, Jolanta Slowikowska-Hilczar⁷⁷, Przemysław Słusarczyk⁴²⁵, Liam Smeeth⁵⁵, Marieke B. Snijder³⁸, Hung-Kwan So²⁸⁶, Eugène Sobngwi⁵⁶, Stefan Söderberg²²⁸, Moesijanti Y. E. Soekatri⁵²⁵, Agustinus Soemantri⁵²⁷, Vincenzo Solfrizzi⁵²⁷, Emily Sonestedt²⁴⁸, Yi Song²⁹⁵, Thorkild I. A. Sørensen⁵⁸, Charles Sossa Jérôme⁵²⁸, Aïcha Soumaré⁵²⁹, Angela Spinelli¹⁹⁹, Igor Spiroski⁵³⁰, Jan A. Staessen⁵³¹, Hanspeter Stamm⁵³², Maria G. Stathopoulou⁵³³, Kaspar Staub¹¹⁸, Bill Stavreski³¹⁰, Jostein Steene-Johannessen⁵⁷, Peter Stehle⁵³⁴, Aryeh D. Stein³⁹⁹, George S. Stergiou⁵³⁵, Jochanan Stessman³⁰⁵, Doris Stöckl²⁰¹, Tanja Stocks²⁴⁸, Jakub Stokwiszewski⁵³⁶, Gareth Stratton⁵³⁷, Karien Stronks³⁸, Maria Wany Strufaldi²³⁰, Lela Sturua⁵²⁰, Ramón Suárez-Medina²⁵⁴, Chien-An Sun⁵³⁸, Johan Sundström³⁷⁴, Yn-Tz Sung²⁸⁷, Jordi Sunyer⁵⁰, Paibul Suriyawongpaisal³⁴, Boyd A. Swinburn⁸⁸, Rody G. Sy⁴⁸⁸, René Charles Sylva⁵³⁹, Lucjan Szponar⁴⁴⁸, E. Shyong Tai³⁶⁵, Mari-Liis Tammesoo²²⁵, Abdonas Tamasiusinas⁹³, Eng Joo Tan¹⁷, Xun Tang²⁹⁵, Frank Tanser⁵⁴⁰, Yong Tao²⁹⁵, Mohammed Rasoul Tarawneh⁵⁴¹, Jakob Tarp⁵⁷, Carolina B. Tarqui-Mamani⁵⁰⁷, Radka Taxová Braunerová³⁵⁴, Anne Taylor²⁴⁷, Félicité Tchibindat⁴³⁶, William R. Tebar¹⁶⁷, Grethe Tell²⁷⁶, Tania Tello⁹, Holger Theobald¹⁴⁴, Xenophon Theodoridis²⁵⁸, Lutgarde Thijs⁵³¹, Betina H. Thuesen⁷⁵, Lubica Tichá⁵⁴², Erik J. Timmermans³³⁰, Anne Tjønneland²⁷³, Hanna K. Tolonen²¹⁴, Janne S. Tolstrup¹⁰⁵, Murat Topbas¹³⁹, Roman Topór-Madry²⁵⁹, María José Tormo⁵⁴³

- Michael J. Tornaritis²⁷², Maties Torrent⁵⁴⁴, Stefania Toselli⁵⁴⁵, Pierre Traissac¹⁹¹, Dimitrios Trichopoulos^{12,576}, Antonia Trichopoulou⁵⁴⁶, Oanh T. H. Trinh⁴³⁸, Atul Trivedi⁵⁴⁷, Yu-Hsiang Tsao³⁷², Lechaba Tshupo⁵⁴⁸, Maria Tsigga²⁷⁴, Shoichiro Tsugane⁴⁴², Marshall K. Tulloch-Reid²¹¹, Fikru Tullu⁵⁴⁹, Tomi-Pekka Tuomainen⁵²⁶, Jaakko Tuomilehto⁵⁵⁰, Maria L. Turley⁵⁵¹, Per Tynelius²³, Themistoklis Tzotzas³²¹, Christophe Tzourio⁵²⁹, Peter Ueda¹², Eunice E. Ugel⁵⁵², Flora A. M. Ukoji⁵⁵³, Hanno Ulmer³³⁵, Belgin Unal⁵⁵⁴, Hannu M. T. Uusitalo⁵⁵⁵, Justina Vaitkeviciute⁹³, Gonzalo Valdivia²²¹, Susana Vale⁵⁵⁶, Damaskini Valvi¹², Yvonne T. van der Schouw⁵⁵⁷, Koen Van Herck¹²², Hoang Van Minh³⁵⁷, Lenie van Rossem⁵⁵⁸, Natasja M. Van Schoor³³⁰, Irene G. M. van Valkengoed³⁸, Dirk Vanderschueren¹⁷³, Diego Vanuzzo⁴⁷⁰, Gregorio Varela-Moreiras⁵⁰¹, Patricia Varona-Pérez²⁵⁴, Lars Vatten³⁰⁶, Tomas Vega³⁷⁹, Toomas Veidebaum³⁷⁶, Gustavo Velasquez-Melendez²⁴⁴, Biruta Velika⁴⁷⁷, Giovanni Veronesi²⁴⁶, W. M. Monique Verschuren¹⁰⁸, Cesar G. Victora⁶⁸, Giovanni Viegi⁵⁵⁹, Lucie Viet¹⁰⁸, Paolo Vineis¹, Jesus Vioque⁵⁶⁰, Jyrki K. Virtanen³²⁶, Marjolein Visser²⁹⁸, Sophie Visvikis-Siest⁵³³, Bharathi Viswanathan⁵⁶¹, Tiina Vlasoff⁵⁶², Peter Vollenweider³⁹⁶, Henry Völzke³⁷⁸, Ari Voutilainen³²⁶, Sari Voutilainen³²⁶, Martine Vrijheid⁵⁰, Tanja G. M. Vrijkotte²⁹⁷, Alisha N. Wade⁵⁶³, Aline Wagner⁴¹⁶, Thomas Waldhör⁵¹⁶, Janette Walton¹³², Wan Mohamad Wan Bebakar²²⁷, Wan Nazaimoon Wan Mohamud⁵⁶⁴, Rildo S. Wanderley Jr⁸³, Ming-Dong Wang⁴⁹⁶, Qian Wang⁵⁶⁵, Xiangjun Wang⁵⁶⁶, Ya Xing Wang²⁶⁷, Ying-Wei Wang¹⁶³, S. Goya Wannamethee¹¹⁰, Nicholas Wareham³³³, Adelheid Weber⁹¹, Deepa Weerasekera⁵⁵¹, Daniel Weghuber⁵⁶⁷, Wenbin Wei²⁶⁷, Peter H. Whincup⁵⁶⁸, Kurt Widham⁵¹⁶, Indah S. Widyahening⁵⁶⁹, Andrzej Wiecek¹⁶⁸, Alet H. Wilja¹⁰⁸, Rainford J. Wilks²¹¹, Johann Willeit³³⁵, Peter Willeit³³⁵, Tom Wilsaard⁴⁰², Bogdan Wojtyniak⁵³⁶, Jyh Elin Wong³²⁰, Tien Yin Wong¹⁵³, Roy A. Wong-McClure²⁶, Jean Woo²⁸⁷, Mark Woodward^{524,159}, Frederick C. Wu⁴⁴⁹, Jianfeng Wu⁹⁸, Shouling Wu¹⁵⁸, Haiquan Xu⁵⁷⁰, Liang Xu²⁶⁷, Uruwan Yamborisut³⁴, Weili Yan⁵⁷¹, Ling Yang¹⁵⁹, Xiaoguang Yang²⁷⁸, Yang Yang⁵⁶⁶, Nazan Yardim¹⁴⁹, Mehdi Yaseri⁷³, Xingwang Ye³⁷³, Panayiotis K. Yiallourou⁵⁷², Agneta Yngve³⁷⁴, Moein Yousefi³⁹, Akihiro Yoshihara³⁰⁴, Qi Sheng You²⁶⁷, San-Lin You⁵³⁸, Novie O. Younger-Coleman²¹¹, Ahmad Faudzi Yusoff²⁵, Luciana Zaccagni²⁶¹, Vassilis Zafropoulos³⁹³, Farhad Zamani⁵⁷³, Sabina Zamboni³⁹², Antonis Zampelas³⁸⁷, Hana Zamrazilova³⁵⁴, Maria Elisa Zapata¹⁴⁵, Ko Ko Zaw³⁶³, Tomasz Zdrojewski⁷⁸, Tajana Zeljkovic Vrkic³⁰³, Yi Zeng^{157,295}, Dong Zhao³⁷⁵, Wenhua Zhao²⁷⁸, Wei Zheng¹³⁵, Yingfeng Zheng⁵⁰³, Bekbolat Zholdin⁵⁷⁴, Maigeng Zhou²⁷⁸, Dan Zhu⁵⁷⁵, Baurzhan Zhussupov⁸⁷, Esther Zimmermann⁷⁵, Julio Zuñiga Cisneros⁴²⁷ & Majid Ezzati^{1*}
- ¹Imperial College London, London, UK. ²University of Kent, Canterbury, UK. ³Middlesex University, London, UK. ⁴University of California Berkeley, Berkeley, CA, USA. ⁵World Health Organization, Geneva, Switzerland. ⁶Seoul National University, Seoul, South Korea. ⁷University of Zagreb, Zagreb, Croatia. ⁸US Centers for Disease Control and Prevention, Atlanta, GA, USA. ⁹Universidad Peruana Cayetano Heredia, Lima, Peru. ¹⁰Ag Khan University, Karachi, Pakistan. ¹¹The Hospital for Sick Children, Toronto, Ontario, Canada. ¹²Harvard T. H. Chan School of Public Health, Boston, MA, USA. ¹³Ministry of Health, Victoria, Seychelles. ¹⁴University of Lausanne, Lausanne, Switzerland. ¹⁵Victor Babeş University of Medicine and Pharmacy Timisoara, Timisoara, Romania. ¹⁶The University of the West Indies, Cave Hill, Barbados. ¹⁷University of Sydney, Sydney, New South Wales, Australia. ¹⁸National Institutes of Biomedical Innovation, Health and Nutrition, Tokyo, Japan. ¹⁹South African Medical Research Council, Cape Town, South Africa. ²⁰CMR-National Institute of Nutrition, Hyderabad, India. ²¹Brown University, Providence, RI, USA. ²²Ain Shams University, Cairo, Egypt. ²³Karolinska Institutet, Stockholm, Sweden. ²⁴University of Ljubljana, Ljubljana, Slovenia. ²⁵Ministry of Health Malaysia, Kuala Lumpur, Malaysia. ²⁶Caja Costarricense de Seguro Social, San José, Costa Rica. ²⁷Al-Quds University, East Jerusalem, Palestine. ²⁸National Center of Public Healthcare, Nur-Sultan, Kazakhstan. ²⁹Center for Diabetes and Endocrine Care, Srinagar, India. ³⁰Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria. ³¹Birzeit University, Birzeit, Palestine. ³²Instituto Mexicano del Seguro Social, Mexico City, Mexico. ³³Flinders University, Adelaide, South Australia, Australia. ³⁴Mahidol University, Nakhon Pathom, Thailand. ³⁵BRAC University, Dhaka, Bangladesh. ³⁶Food and Nutrition Research Institute, Taguig, The Philippines. ³⁷Instituto Nacional de Ciencias Médicas y Nutrición, Mexico City, Mexico. ³⁸University of Amsterdam, Amsterdam, The Netherlands. ³⁹Tehran University of Medical Sciences, Tehran, Iran. ⁴⁰Non-Communicable Diseases Research Center, Tehran, Iran. ⁴¹University of Bremen, Bremen, Germany. ⁴²The National Center for Diabetes, Endocrinology and Genetics, Amman, Jordan. ⁴³Aldara Hospital and Medical Center, Riyadh, Saudi Arabia. ⁴⁴King Abdullah International Medical Research Center, Riyadh, Saudi Arabia. ⁴⁵King Saud University, Riyadh, Saudi Arabia. ⁴⁶Universiti Malaysia Sabah, Kota Kinabalu, Malaysia. ⁴⁷Luxembourg Institute of Health, Strassen, Luxembourg. ⁴⁸Kuwait Institute for Scientific Research, Safat, Kuwait. ⁴⁹King Abdulaziz University, Jeddah, Saudi Arabia. ⁵⁰ISGlobal Centre for Research in Environmental Epidemiology, Barcelona, Spain. ⁵¹World Health Organization Regional Office for the Eastern Mediterranean, Cairo, Egypt. ⁵²Bombay Hospital and Medical Research Centre, Mumbai, India. ⁵³University of Lille, Lille, France. ⁵⁴Lille University Hospital, Lille, France. ⁵⁵London School of Hygiene & Tropical Medicine, London, UK. ⁵⁶Western Norway University of Applied Sciences, Sogndal, Norway. ⁵⁷Norwegian School of Sport Sciences, Oslo, Norway. ⁵⁸University of Copenhagen, Copenhagen, Denmark. ⁵⁹Madras Diabetes Research Foundation, Chennai, India. ⁶⁰Zahedan University of Medical Sciences, Zahedan, Iran. ⁶¹National Institute of Public Health, Tunis, Tunisia. ⁶²Institute of Public Health of the University of Porto, Porto, Portugal. ⁶³Norwegian Institute of Public Health, Oslo, Norway. ⁶⁴University of Massachusetts, Amherst, MA, USA. ⁶⁵Abt Associates, Kathmandu, Nepal. ⁶⁶University of Iceland, Reykjavik, Iceland. ⁶⁷University of Yaoundé 1, Yaoundé, Cameroon. ⁶⁸Federal University of Pelotas, Pelotas, Brazil. ⁶⁹University of Medicine 1, Yangon, Myanmar. ⁷⁰University of Oulu, Oulu, Finland. ⁷¹Regional Authority of Public Health, Banská Bystrica, Slovakia. ⁷²University of Porto Medical School, Porto, Portugal. ⁷³Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁷⁴Indian Council of Medical Research, New Delhi, India. ⁷⁵Bispebjerg and Frederiksberg Hospital, Copenhagen, Denmark. ⁷⁶University of Science and Technology, Sana'a, Yemen. ⁷⁷Medical University of Lodz, Lodz, Poland. ⁷⁸Medical University of Gdansk, Gdansk, Poland. ⁷⁹Universidad Autónoma de Madrid, Madrid, Spain. ⁸⁰University of Palermo, Palermo, Italy. ⁸¹Pan American Health Organization, Washington, DC, USA. ⁸²Mohammed V University of Rabat, Rabat, Morocco. ⁸³University of Pernambuco, Recife, Brazil. ⁸⁴Dalhousie University, Halifax, Nova Scotia, Canada. ⁸⁵Jordan University of Science and Technology, Irbid, Jordan. ⁸⁶Federal University of Maranhão, São Luís, Brazil. ⁸⁷Kazakh National Medical University, Almaty, Kazakhstan. ⁸⁸University of Auckland, Auckland, New Zealand. ⁸⁹University College Dublin, Dublin, Ireland. ⁹⁰University of Tunis El Manar, Tunis, Tunisia. ⁹¹Federal Ministry of Labour, Social Affairs, Health and Consumer Protection, Vienna, Austria. ⁹²Cafam University Foundation, Bogotá, Colombia. ⁹³Lithuanian University of Health Sciences, Kaunas, Lithuania. ⁹⁴University of São Paulo, São Paulo, Brazil. ⁹⁵B. J. Medical College, Ahmedabad, India. ⁹⁶Chirayu Medical College, New Delhi, India. ⁹⁷Sunder Lal Jain Hospital, Delhi, India. ⁹⁸Shandong University of Traditional Chinese Medicine, Shandong, China. ⁹⁹Shanghai Jiao-Tong University School of Medicine, Shanghai, China. ¹⁰⁰Institute of Medical Research and Medicinal Plant Studies, Yaoundé, Cameroon. ¹⁰¹Ufa Eye Research Institute, Ufa, Russia. ¹⁰²Nepal Health Research Council, Kathmandu, Nepal. ¹⁰³University of Montenegro, Niksic, Montenegro. ¹⁰⁴University of Greenland, Nuuk, Greenland. ¹⁰⁵University of Southern Denmark, Odense, Denmark. ¹⁰⁶University of Oslo, Oslo, Norway. ¹⁰⁷University of Gothenburg, Gothenburg, Sweden. ¹⁰⁸National Institute for Public Health and the Environment, Bilthoven, The Netherlands. ¹⁰⁹University of Turin, Turin, Italy. ¹¹⁰University College London, London, UK. ¹¹¹Liverpool John Moores University, Liverpool, UK. ¹¹²Nanyang Technological University, Singapore, Singapore. ¹¹³German Institute of Human Nutrition, Potsdam, Germany. ¹¹⁴Universidad de la República, Montevideo, Uruguay. ¹¹⁵CEMIC, Buenos Aires, Argentina. ¹¹⁶IRCCS Neuromed, Pozzilli, Italy. ¹¹⁷Toulouse University School of Medicine, Toulouse, France. ¹¹⁸University of Zurich, Zurich, Switzerland. ¹¹⁹University Hospital of Varese, Varese, Italy. ¹²⁰University Hospital KU Leuven, Leuven, Belgium. ¹²¹Flemish Agency for Care and Health, Brussels, Belgium. ¹²²Ghent University, Ghent, Belgium. ¹²³FrieslandCampina, Amersfoort, The Netherlands. ¹²⁴Universidad Central de Venezuela, Caracas, Venezuela. ¹²⁵Bielefeld University, Bielefeld, Germany. ¹²⁶World Health Organization Regional Office for Europe, Copenhagen, Denmark. ¹²⁷German Cancer Research Center, Heidelberg, Germany. ¹²⁸The Fred Hollows Foundation, Auckland, New Zealand. ¹²⁹University of Medicine and Pharmacy Bucharest, Bucharest, Romania. ¹³⁰University College Copenhagen, Copenhagen, Denmark. ¹³¹Institute of Public Health, Tirana, Albania. ¹³²Cork Institute of Technology, Cork, Ireland. ¹³³Universidad de La Laguna, Tenerife, Spain. ¹³⁴University of Malta, Pietà, Malta. ¹³⁵Vanderbilt University, Nashville, TN, USA. ¹³⁶Ministry of Health, Tongatapu, Tonga. ¹³⁷Canadian Fitness and Lifestyle Research Institute, Ottawa, Ontario, Canada. ¹³⁸Hospital Santa Maria, Lisbon, Portugal. ¹³⁹Karadeniz Technical University, Trabzon, Turkey. ¹⁴⁰Istanbul University, Istanbul, Turkey. ¹⁴¹Universidade Federal de Juiz de Fora, Juiz de Fora, Brazil. ¹⁴²Ministry of Public Health, Asunción, Paraguay. ¹⁴³Cardiologia di Mercato S. Severino Hospital, Mercato San Severino, Italy. ¹⁴⁴Karolinska Institutet, Huddinge, Sweden. ¹⁴⁵Centro de Estudios sobre Nutrición Infantil, Buenos Aires, Argentina. ¹⁴⁶University of Porto, Porto, Portugal. ¹⁴⁷Santiago de Compostela University, Santiago de Compostela, Spain. ¹⁴⁸Associazione Calabrese di Epatologia, Reggio Calabria, Italy. ¹⁴⁹Ministry of Health, Ankara, Turkey. ¹⁵⁰Food and Agriculture Organization of the United Nations, Rome, Italy. ¹⁵¹Federal University of Rio Grande, Rio Grande, Brazil. ¹⁵²India Diabetes Research Foundation, Chennai, India. ¹⁵³Duke-NUS Medical School, Singapore, Singapore. ¹⁵⁴National Institute of Medical Statistics, New Delhi, India. ¹⁵⁵Academia Sinica, Taipei, Taiwan. ¹⁵⁶Capital Institute of Pediatrics, Beijing, China. ¹⁵⁷Duke University, Durham, NC, USA. ¹⁵⁸Kailuan General Hospital, Tangshan, China. ¹⁵⁹University of Oxford, Oxford, UK. ¹⁶⁰The Gertner Institute for Epidemiology and Health Policy Research, Ramat Gan, Israel. ¹⁶¹National Center of Public Health and Analyses, Sofia, Bulgaria. ¹⁶²University of Bern, Lausanne, Switzerland. ¹⁶³Ministry of Health and Welfare, Taipei, Taiwan. ¹⁶⁴Murcia Health Council, Murcia, Spain. ¹⁶⁵Seoul National University College of Medicine, Seoul, South Korea. ¹⁶⁶Korea Centers for Disease Control and Prevention, Cheongju-si, South Korea. ¹⁶⁷Universidade Estadual Paulista, Presidente Prudente, Brazil. ¹⁶⁸Medical University of Silesia, Katowice, Poland. ¹⁶⁹Charles University in Prague, Prague, Czech Republic. ¹⁷⁰Thomayer Hospital, Prague, Czech Republic. ¹⁷¹Primary Health Care, Floriana, Malta. ¹⁷²Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. ¹⁷³Katholieke Universiteit Leuven, Leuven, Belgium. ¹⁷⁴Statistics Canada, Ottawa, Ontario, Canada. ¹⁷⁵Agency for Preventive and Social Medicine, Bregenz, Austria. ¹⁷⁶Universidade Federal de Santa Catarina, Florianópolis, Brazil. ¹⁷⁷University of Southampton, Southampton, UK. ¹⁷⁸Institut Pasteur de Lille, Lille, France. ¹⁷⁹Malawi Epidemiology and Intervention Research Unit, Lilongwe, Malawi. ¹⁸⁰CIBEROBN, Madrid, Spain. ¹⁸¹National Institute of Public Health, Bucharest, Romania. ¹⁸²Eduardo Mondlane University, Maputo, Mozambique. ¹⁸³National Council of Research, Reggio Calabria, Italy. ¹⁸⁴Indian Statistical Institute, Kolkata, India. ¹⁸⁵Tabriz Health Services Management Centre, Tabriz, Iran. ¹⁸⁶Sciensano, Brussels, Belgium. ¹⁸⁷Academic Medical Center of University of Amsterdam, Amsterdam, The Netherlands. ¹⁸⁸National Research Centre for Preventive Medicine, Moscow, Russia. ¹⁸⁹Erasmus Medical Center Rotterdam, Rotterdam, The Netherlands. ¹⁹⁰University of Montreal, Montreal, Québec, Canada. ¹⁹¹Institut de Recherche pour le Développement, Montpellier, France. ¹⁹²French Public Health Agency, St Maurice, France. ¹⁹³Mediterranea Cardiocentro, Naples, Italy. ¹⁹⁴Universidade do Vale do Rio dos Sinos, São Leopoldo, Brazil. ¹⁹⁵National Council of Scientific and Technical Research, Tandil, Argentina. ¹⁹⁶Ministry of Health and Medical Education, Tehran, Iran. ¹⁹⁷National Institute of Nutrition, Hanoi, Vietnam. ¹⁹⁸University of Queensland, Brisbane, Queensland, Australia. ¹⁹⁹Istituto Superiore di Sanità, Rome, Italy. ²⁰⁰Universidad de Cuenca,

- Cuenca, Ecuador. ²⁰¹Helmholtz Zentrum München, Munich, Germany. ²⁰²Ministère de la Santé et de la Lutte Contre le Sida, Abidjan, Côte d'Ivoire. ²⁰³The Cardinal Wyszyński Institute of Cardiology, Warsaw, Poland. ²⁰⁴Beijing Center for Disease Prevention and Control, Beijing, China. ²⁰⁵BIDMC, Boston, MA, USA. ²⁰⁶University of Latvia, Riga, Latvia. ²⁰⁷Ministry of Health and Medical Services, Gizo, Solomon Islands. ²⁰⁸University of Benin, Benin City, Nigeria. ²⁰⁹University of Skövde, Skövde, Sweden. ²¹⁰National Institute of Nutrition and Food Technology, Tunis, Tunisia. ²¹¹The University of the West Indies, Kingston, Jamaica. ²¹²University of California Davis, Davis, CA, USA. ²¹³University of Stellenbosch, Cape Town, South Africa. ²¹⁴National Institute for Health and Welfare, Helsinki, Finland. ²¹⁵Queen's University of Belfast, Belfast, UK. ²¹⁶Shiraz University of Medical Sciences, Shiraz, Iran. ²¹⁷Centro de Salud Villanueva Norte, Badajoz, Spain. ²¹⁸Hospital Don Benito-Villanueva de la Serena, Badajoz, Spain. ²¹⁹Ministry of Health, Buenos Aires, Argentina. ²²⁰Council for Agricultural Research and Economics, Rome, Italy. ²²¹Pontificia Universidad Católica de Chile, Santiago, Chile. ²²²Institute of Mother and Child, Warsaw, Poland. ²²³University of Basel, Basel, Switzerland. ²²⁴Swiss TPH, Basel, Switzerland. ²²⁵University of Tartu, Tartu, Estonia. ²²⁶Instituto Nacional de Salud Pública, Cuernavaca, Mexico. ²²⁷Universiti Sains Malaysia, Kelantan, Malaysia. ²²⁸Umeå University, Jmeå, Sweden. ²²⁹Georgia College and State University, Milledgeville, GA, USA. ²³⁰Federal University of São Paulo, São Paulo, Brazil. ²³¹Hospital Universitario Son Espases, Palma, Spain. ²³²Hospital de Clínicas de Porto Alegre, Porto Alegre, Brazil. ²³³Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil. ²³⁴Kindai University, Osaka-Sayama, Japan. ²³⁵Kyoto University, Kyoto, Japan. ²³⁶Medical University of Warsaw, Warsaw, Poland. ²³⁷Ministry of Health, Rome, Italy. ²³⁸University of Catania, Catania, Italy. ²³⁹CIBER en Epidemiología y Salud Pública, Alicante, Spain. ²⁴⁰Africa Health Research Institute, Mtubatuba, South Africa. ²⁴¹Geneva University Hospitals, Geneva, Switzerland. ²⁴²CIBER en Epidemiología y Salud Pública, Barcelona, Spain. ²⁴³Australian Bureau of Statistics, Canberra, Australian Capital Territory, Australia. ²⁴⁴Universidade Federal de Minas Gerais, Belo Horizonte, Brazil. ²⁴⁵Wageningen University, Wageningen, The Netherlands. ²⁴⁶University of Insubria, Varese, Italy. ²⁴⁷University of Adelaide, Adelaide, South Australia, Australia. ²⁴⁸Lund University, Lund, Sweden. ²⁴⁹Ministry of Health, Jerusalem, Israel. ²⁵⁰McGill University, Montreal, Québec, Canada. ²⁵¹Universidad Autónoma de Santo Domingo, Santo Domingo, Dominican Republic. ²⁵²Universidad Politécnica e Madrid, Madrid, Spain. ²⁵³The Andes Clinic of Cardio-Metabolic Studies, Merida, Venezuela. ²⁵⁴Instituto Nacional de Higiene, Epidemiología y Microbiología, Havana, Cuba. ²⁵⁵Ministry of Health, Lisbon, Portugal. ²⁵⁶Institute for Clinical and Experimental Medicine, Prague, Czech Republic. ²⁵⁷Children's Memorial Health Institute, Warsaw, Poland. ²⁵⁸Aristotle University of Thessaloniki, Thessaloniki, Greece. ²⁵⁹Jagiellonian University Medical College, Kraków, Poland. ²⁶⁰National Center of Cardiovascular Diseases, Beijing, China. ²⁶¹University of Ferrara, Ferrara, Italy. ²⁶²Icelandic Heart Association, Kopavogur, Iceland. ²⁶³Universidad Icesi, Cali, Colombia. ²⁶⁴State University of Montes Claros, Montes Claros, Brazil. ²⁶⁵King's College London, London, UK. ²⁶⁶International Agency for Research on Cancer, Lyon, France. ²⁶⁷Capital Medical University, Beijing, China. ²⁶⁸Healis-Sekhsaria Institute for Public Health, Navi Mumbai, India. ²⁶⁹Eternal Heart Care Centre and Research Institute, Jaipur, India. ²⁷⁰University of Ibadan, Ibadan, Nigeria. ²⁷¹Institute for Clinical Effectiveness and Health Policy, Buenos Aires, Argentina. ²⁷²Research and Education Institute of Child Health, Nicosia, Cyprus. ²⁷³Danish Cancer Society Research Centre, Copenhagen, Denmark. ²⁷⁴Alexander Technological Educational Institute, Thessaloniki, Greece. ²⁷⁵Kyushu University, Fukuoka, Japan. ²⁷⁶University of Bergen, Bergen, Norway. ²⁷⁷Tulane University, New Orleans, LA, USA. ²⁷⁸Chinese Center for Disease Control and Prevention, Beijing, China. ²⁷⁹University of Pécs, Pécs, Hungary. ²⁸⁰Danish Health Authority, Copenhagen, Denmark. ²⁸¹Joep Lange Institute, Amsterdam, The Netherlands. ²⁸²Oulu University Hospital, Oulu, Finland. ²⁸³Universidad Autónoma de Bucaramanga, Bucaramanga, Colombia. ²⁸⁴ETH Zurich, Zurich, Switzerland. ²⁸⁵Chronic Diseases Research Center, Tehran, Iran. ²⁸⁶University of Hong Kong, Hong Kong, China. ²⁸⁷The Chinese University of Hong Kong, Hong Kong, China. ²⁸⁸University of Western Australia, Perth, Western Australia, Australia. ²⁸⁹Kingston Health Sciences Centre, Kingston, Ontario, Canada. ²⁹⁰Heart Institute, São Paulo, Brazil. ²⁹¹Fundación Oftalmológica de Santander, Santander, Colombia. ²⁹²University Oran 1, Oran, Algeria. ²⁹³Independent Public Health Specialist, Nay Pyi Taw, Myanmar. ²⁹⁴Ministry of Health and Sports, Nay Pyi Taw, Myanmar. ²⁹⁵Peking University, Beijing, China. ²⁹⁶CIBER en Epidemiología y Salud Pública, Murcia, Spain. ²⁹⁷Amsterdam UMC of University of Amsterdam, Amsterdam, The Netherlands. ²⁹⁸Vrije Universiteit Amsterdam, Amsterdam, The Netherlands. ²⁹⁹American University of Beirut, Beirut, Lebanon. ³⁰⁰CIBER en Epidemiología y Salud Pública, in Sebastian, Spain. ³⁰¹Cairo University, Cairo, Egypt. ³⁰²The University of Tokyo, Tokyo, Japan. ³⁰³University Hospital Centre Zagreb, Zagreb, Croatia. ³⁰⁴Niigata University, Niigata, Japan. ³⁰⁵Hadassah University Medical Center, Jerusalem, Israel. ³⁰⁶Norwegian University of Science and Technology, Trondheim, Norway. ³⁰⁷The University of Melbourne, Melbourne, Victoria, Australia. ³⁰⁸Sports University of Tirana, Tirana, Albania. ³⁰⁹University of Zagreb School of Medicine, Zagreb, Croatia. ³¹⁰Heart Foundation, Melbourne, Victoria, Australia. ³¹¹National Health Insurance Service, Wonju, South Korea. ³¹²Guangzhou 12th Hospital, Guangzhou, China. ³¹³Universidad Eugenio María de Hostos, Santo Domingo, Dominican Republic. ³¹⁴Simon Fraser University, Burnaby, British Columbia, Canada. ³¹⁵Ruprecht-Karls-University of Heidelberg, Heidelberg, Germany. ³¹⁶World Health Organization Country Office, Delhi, India. ³¹⁷Institute of Public Health of Serbia, Belgrade, Serbia. ³¹⁸University of Opole, Opole, Poland. ³¹⁹University of Crete, Heraklion, Greece. ³²⁰Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia. ³²¹Hellenic Medical Association for Obesity, Athens, Greece. ³²²Maharaja Gunj Medical Campus, Kathmandu, Nepal. ³²³Aarhus University, Aarhus, Denmark. ³²⁴Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA. ³²⁵Pennington Biomedical Research Center, Baton Rouge, LA, USA. ³²⁶University of Eastern Finland, Kuopio, Finland. ³²⁷National Institute of Epidemiology, Chennai, India. ³²⁸University of Münster, Münster, Germany. ³²⁹Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan, Iran. ³³⁰Amsterdam Public Health Research Institute, Amsterdam, The Netherlands. ³³¹Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan. ³³²Research Institute of Child Nutrition, Dortmund, Germany. ³³³University of Cambridge, Cambridge, UK. ³³⁴Hypertension Research Center, Isfahan, Iran. ³³⁵Medical University of Innsbruck, Innsbruck, Austria. ³³⁶Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania. ³³⁷National Cancer Center, Goyang-si, South Korea. ³³⁸Statistics Austria, Vienna, Austria. ³³⁹B. P. Koirala Institute of Health Sciences, Dharan, Nepal. ³⁴⁰University of Vienna, Vienna, Austria. ³⁴¹Oulu Deaconess Institute Foundation, Oulu, Finland. ³⁴²Tartu University Clinics, Tartu, Estonia. ³⁴³Kansai Medical University, Osaka-Sayama, Japan. ³⁴⁴National Institute of Pharmacy and Nutrition, Budapest, Hungary. ³⁴⁵Ministry of Health and Quality of Life, Port Louis, Mauritius. ³⁴⁶Polish Academy of Sciences Anthropology Unit, Wrocław, Poland. ³⁴⁷University Hospital Ulm, Ulm, Germany. ³⁴⁸University of Groningen, Groningen, The Netherlands. ³⁴⁹North-West University, Potchefstroom, South Africa. ³⁵⁰National Institute of Public Health, Prague, Czech Republic. ³⁵¹University of Jyväskylä, Jyväskylä, Finland. ³⁵²Institute of Public Health of Montenegro, Podgorica, Montenegro. ³⁵³Amrita Institute of Medical Sciences, Cochin, India. ³⁵⁴Institute of Endocrinology, Prague, Czech Republic. ³⁵⁵All India Institute of Medical Sciences, New Delhi, India. ³⁵⁶African Population and Health Research Center, Nairobi, Kenya. ³⁵⁷Hanoi University of Public Health, Hanoi, Vietnam. ³⁵⁸Higher Institute of Nursing Professions and Technical Health, Rabat, Morocco. ³⁵⁹National Institute of Public Health of Algeria, Algiers, Algeria. ³⁶⁰Croatian National Institute of Public Health, Zagreb, Croatia. ³⁶¹Sahlgrenska Academy, Gothenburg, Sweden. ³⁶²Endocrinology and Metabolism Research Center, Tehran, Iran. ³⁶³University of Public Health, Yangon, Myanmar. ³⁶⁴International Food Policy Research Institute, Dakar, Senegal. ³⁶⁵National University of Singapore, Singapore, Singapore. ³⁶⁶Hong Kong Polytechnic University, Hong Kong, China. ³⁶⁷Tampere University Hospital, Tampere, Finland. ³⁶⁸University of Douala, Douala, Cameroon. ³⁶⁹University of Cape Town, Cape Town, South Africa. ³⁷⁰West Virginia University, Morgantown, WV, USA. ³⁷¹Oswaldo Cruz Foundation Rene Rachou Research Institute, Belo Horizonte, Brazil. ³⁷²National Taiwan University, Taipei, Taiwan. ³⁷³University of Chinese Academy of Sciences, Shanghai, China. ³⁷⁴Uppsala University, Uppsala, Sweden. ³⁷⁵Capital Medical University Beijing An Zhen Hospital, Beijing, China. ³⁷⁶National Institute for Health Development, Tallinn, Estonia. ³⁷⁷Universidad San Martín de Porres, Lima, Peru. ³⁷⁸University Medicine of Greifswald, Greifswald, Germany. ³⁷⁹Consejería de Sanidad Junta de Castilla y León, Valladolid, Spain. ³⁸⁰Norrbotten County Council, Luleå, Sweden. ³⁸¹University of Uppsala, Uppsala, Sweden. ³⁸²Universidade Federal de Ouro Preto, Ouro Preto, Brazil. ³⁸³University of Coimbra, Coimbra, Portugal. ³⁸⁴The Jikei University School of Medicine, Tokyo, Japan. ³⁸⁵National Research Council, Padua, Italy. ³⁸⁶Baker Heart and Diabetes Institute, Melbourne, Victoria, Australia. ³⁸⁷Agricultural University of Athens, Athens, Greece. ³⁸⁸Hospital Israelita Albert Einstein, São Paulo, Brazil. ³⁸⁹Institute of Internal and Preventive Medicine, Novosibirsk, Russia. ³⁹⁰Harokopio University, Athens, Greece. ³⁹¹University of Otago, Dunedin, New Zealand. ³⁹²University of Padua, Padua, Italy. ³⁹³Technological Educational Institute of Crete, Heraklion, Greece. ³⁹⁴Loughborough University, Loughborough, UK. ³⁹⁵Ministry of Health, Nicosia, Cyprus. ³⁹⁶Lausanne University Hospital, Lausanne, Switzerland. ³⁹⁷CIBERCV, Barcelona, Spain. ³⁹⁸Mary Immaculate College, Limerick, Ireland. ³⁹⁹Emory University, Atlanta, GA, USA. ⁴⁰⁰Hungarian Society of Sports Medicine, Budapest, Hungary. ⁴⁰¹Sher-i-Kashmir Institute of Medical Sciences, Srinagar, India. ⁴⁰²UIT The Arctic University of Norway, Tromsø, Norway. ⁴⁰³National Centre for Disease Informatics and Research, New Delhi, India. ⁴⁰⁴Cape Peninsula University of Technology, Cape Town, South Africa. ⁴⁰⁵University of Rzeszow, Rzeszow, Poland. ⁴⁰⁶University of Edinburgh, Edinburgh, UK. ⁴⁰⁷International Medical University, Shah Alam, Malaysia. ⁴⁰⁸Institut National de la Santé et de la Recherche Médicale, Lille, France. ⁴⁰⁹Robert Koch Institute, Berlin, Germany. ⁴¹⁰Lusófona University, Lisbon, Portugal. ⁴¹¹Democritus University, Alexandroupolis, Greece. ⁴¹²Grigore T. Popa University of Medicine and Pharmacy, Iasi, Romania. ⁴¹³Università degli Studi di Firenze, Florence, Italy. ⁴¹⁴Isfahan Cardiovascular Research Center, Isfahan, Iran. ⁴¹⁵Strasbourg University Hospital, Strasbourg, France. ⁴¹⁶University of Strasbourg, Strasbourg, France. ⁴¹⁷Mulago Hospital, Kampala, Uganda. ⁴¹⁸Instituto Nacional de Salud Pública, Mexico City, Mexico. ⁴¹⁹University of Limpopo, Sovenga, South Africa. ⁴²⁰Seoul National University Children's Hospital, Seoul, South Korea. ⁴²¹University Medical Science, Havana, Cuba. ⁴²²Universidad de Zaragoza, Zaragoza, Spain. ⁴²³RCSI, Dublin, Ireland. ⁴²⁴La Trobe University, Melbourne, Victoria, Australia. ⁴²⁵International Institute of Molecular and Cell Biology, Warsaw, Poland. ⁴²⁶Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. ⁴²⁷Gorgas Memorial Institute of Public Health, Panama City, Panama. ⁴²⁸World Health Organization Country Office, Lilongwe, Malawi. ⁴²⁹Department of Public Health, Nay Pyi Taw, Myanmar. ⁴³⁰University of Brescia, Brescia, Italy. ⁴³¹Ministry of Health and Social Protection, Dushanbe, Tajikistan. ⁴³²Bushehr University of Medical Sciences, Bushehr, Iran. ⁴³³Ulm University, Ulm, Germany. ⁴³⁴Kobe University, Kobe, Japan. ⁴³⁵Suraj Eye Institute, Nagpur, India. ⁴³⁶UNICEF, Yaoundé, Cameroon. ⁴³⁷National Institute of Hygiene and Epidemiology, Hanoi, Vietnam. ⁴³⁸University of Pharmacy and Medicine, Ho Chi Minh City, Vietnam. ⁴³⁹Hanoi Medical University, Hanoi, Vietnam. ⁴⁴⁰Miami Veterans Affairs Healthcare System, Miami, FL, USA. ⁴⁴¹Heartfile, Islamabad, Pakistan. ⁴⁴²National Cancer Center, Tokyo, Japan. ⁴⁴³Eastern Mediterranean Public Health Network, Amman, Jordan. ⁴⁴⁴State University of Medicine and Pharmacy, Chisinau, Moldova. ⁴⁴⁵Tachikawa General Hospital, Nagaoka, Japan. ⁴⁴⁶Japan Wildlife Research Center, Tokyo, Japan. ⁴⁴⁷University of Vale do Rio dos Sinos, São Leopoldo, Brazil. ⁴⁴⁸National Food and Nutrition Institute, Warsaw, Poland. ⁴⁴⁹University of Manchester, Manchester, UK. ⁴⁵⁰Ministry of Health, Bandar Seri Begawan, Brunei Darussalam. ⁴⁵¹University of Madeira, Funchal, Portugal. ⁴⁵²University of Puerto Rico, San Juan, Puerto Rico. ⁴⁵³Research Center for Prevention and Health, Glostrup, Denmark. ⁴⁵⁴MRC Lifecourse Epidemiology Unit, Southampton, UK. ⁴⁵⁵University of Novi Sad, Novi Sad, Serbia. ⁴⁵⁶Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. ⁴⁵⁷Institute for Social and Preventive Medicine, Lausanne, Switzerland. ⁴⁵⁸Cancer Prevention and Research Institute, Florence, Italy. ⁴⁵⁹University of Wisconsin-Madison, Madison, WI, USA. ⁴⁶⁰IRCCS Casa Sollievo della Sofferenza, Bari, Italy. ⁴⁶¹Zayed University, Abu Dhabi, United Arab Emirates. ⁴⁶²Catholic University of Daegu, Daegu, South Korea. ⁴⁶³University of Medicine, Pharmacy, Science and Technology of Târgu Mureș, Târgu Mureș, Romania. ⁴⁶⁴Jivandeep Hospital, Anand, India. ⁴⁶⁵South African Medical Research Council, Durban, South Africa. ⁴⁶⁶Spanish Food Safety and Nutrition Agency, Madrid, Spain. ⁴⁶⁷Vietnam National Heart Institute, Hanoi, Vietnam. ⁴⁶⁸Leibniz Institute for Prevention Research and Epidemiology - BIPS, Bremen, Germany. ⁴⁶⁹University of Sarajevo, Sarajevo, Bosnia and Herzegovina. ⁴⁷⁰Cardiovascular Prevention Center Udine, Udine, Italy. ⁴⁷¹University Hospital of Pisa, Pisa, Italy. ⁴⁷²Ministry of Health and Medical Services, Honiara, Solomon Islands. ⁴⁷³Public Health Agency of Catalonia, Barcelona, Spain. ⁴⁷⁴Institut

- Hospital del Mar d'Investigacions Mèdiques, Barcelona, Spain. ⁴⁷⁵Digestive Oncology Research Center, Tehran, Iran. ⁴⁷⁶Digestive Disease Research Institute, Tehran, Iran. ⁴⁷⁷Centre for Disease Prevention and Control, Riga, Latvia. ⁴⁷⁸Alborz University of Medical Sciences, Karaj, Iran. ⁴⁷⁹Ministry of Health, Hanoi, Vietnam. ⁴⁸⁰BRAC, Dhaka, Bangladesh. ⁴⁸¹Institute of Epidemiology Disease Control and Research, Dhaka, Bangladesh. ⁴⁸²University of Turku, Turku, Finland. ⁴⁸³Institut Universitari d'Investigació en Atenció Primària Jordi Gol, Girona, Spain. ⁴⁸⁴Universiti Putra Malaysia, Serdang, Malaysia. ⁴⁸⁵University of Malaya, Kuala Lumpur, Malaysia. ⁴⁸⁶National Institute of Public Health, Copenhagen, Denmark. ⁴⁸⁷University of Valencia, Valencia, Spain. ⁴⁸⁸University of the Philippines, Manila, The Philippines. ⁴⁸⁹Slovak Academy of Sciences, Bratislava, Slovakia. ⁴⁹⁰Nutrition Research Foundation, Barcelona, Spain. ⁴⁹¹Minas Gerais State Secretariat for Health, Belo Horizonte, Brazil. ⁴⁹²Health Center San Agustín, Palma, Spain. ⁴⁹³PharmAccess Foundation, Amsterdam, The Netherlands. ⁴⁹⁴National Institute of Health Doutor Ricardo Jorge, Lisbon, Portugal. ⁴⁹⁵Universidade Nove de Julho, São Paulo, Brazil. ⁴⁹⁶Public Health Agency of Canada, Ottawa, Ontario, Canada. ⁴⁹⁷Canarian Health Service, Tenerife, Spain. ⁴⁹⁸Universidad Industrial de Santander, Santander, Colombia. ⁴⁹⁹Sahlgrenska University Hospital, Gothenburg, Sweden. ⁵⁰⁰Fiji National University, Suva, Fiji. ⁵⁰¹Spanish Nutrition Foundation, Madrid, Spain. ⁵⁰²Institute of Food Sciences of the National Research Council, Avellino, Italy. ⁵⁰³Singapore Eye Research Institute, Singapore, Singapore. ⁵⁰⁴Sitaram Bharti Institute of Science and Research, New Delhi, India. ⁵⁰⁵Maragheh University of Medical Sciences, Maragheh, Iran. ⁵⁰⁶University of Helsinki, Helsinki, Finland. ⁵⁰⁷National Institute of Health, Lima, Peru. ⁵⁰⁸Ministry of Health, Jakarta, Indonesia. ⁵⁰⁹Catalan Department of Health, Barcelona, Spain. ⁵¹⁰Biodonostia Health Research Institute, San Sebastian, Spain. ⁵¹¹Universidade de Lisboa, Lisbon, Portugal. ⁵¹²South Karelia Social and Health Care District, Lappeenranta, Finland. ⁵¹³Cardiovascular Research Institute, Isfahan, Iran. ⁵¹⁴University of São Paulo Clinics Hospital, São Paulo, Brazil. ⁵¹⁵Hospital Italiano de Buenos Aires, Buenos Aires, Argentina. ⁵¹⁶Medical University of Vienna, Vienna, Austria. ⁵¹⁷Rigshospitalet, Copenhagen, Denmark. ⁵¹⁸Lagos State University College of Medicine, Lagos, Nigeria. ⁵¹⁹University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain. ⁵²⁰National Center for Disease Control and Public Health, Tbilisi, Georgia. ⁵²¹National Center for Global Health and Medicine, Tokyo, Japan. ⁵²²Samsung Medical Center, Seoul, South Korea. ⁵²³St Vincent's Hospital, Sydney, New South Wales, Australia. ⁵²⁴University of New South Wales, Sydney, New South Wales, Australia. ⁵²⁵Health Polytechnic Jakarta II Institute, Jakarta, Indonesia. ⁵²⁶Diponegoro University, Semarang, Indonesia. ⁵²⁷University of Bari, Bari, Italy. ⁵²⁸Institut Régional de Santé Publique, Ouidah, Benin. ⁵²⁹University of Bordeaux, Bordeaux, France. ⁵³⁰Institute of Public Health, Skopje, Macedonia. ⁵³¹University of Leuven, Leuven, Belgium. ⁵³²Lamprecht und Stamm Sozialforschung und Beratung AG, Zurich, Switzerland. ⁵³³INSERM, Nancy, France. ⁵³⁴Bonn University, Bonn, Germany. ⁵³⁵Sotiria Hospital, Sotiria, Greece. ⁵³⁶National Institute of Public Health-National Institute of Hygiene, Warsaw, Poland. ⁵³⁷Swansea University, Swansea, UK. ⁵³⁸Fu Jen Catholic University, Taipei, Taiwan. ⁵³⁹National Statistic Office of Cabo Verde, Praia, Cabo Verde. ⁵⁴⁰University of KwaZulu-Natal, Mtubatuba, South Africa. ⁵⁴¹Ministry of Health, Amman, Jordan. ⁵⁴²Comenius University, Bratislava, Slovakia. ⁵⁴³Health Service of Murcia, Murcia, Spain. ⁵⁴⁴IB-SALUT Area de Salut de Menorca, Maó, Spain. ⁵⁴⁵University of Bologna, Bologna, Italy. ⁵⁴⁶Hellenic Health Foundation, Athens, Greece. ⁵⁴⁷Government Medical College, Bhavnagar, India. ⁵⁴⁸Sefako Makgatho Health Science University, Ga-Rankuwa, South Africa. ⁵⁴⁹Addis Ababa University, Addis Ababa, Ethiopia. ⁵⁵⁰Dasman Diabetes Institute, Kuwait City, Kuwait. ⁵⁵¹Ministry of Health, Wellington, New Zealand. ⁵⁵²Universidad Centro-Occidental Lisandro Alvarado, Barquisimeto, Venezuela. ⁵⁵³Meharry Medical College, Nashville, TN, USA. ⁵⁵⁴Dokuz Eylul University, Izmir, Turkey. ⁵⁵⁵University of Tampere Tays Eye Center, Tampere, Finland. ⁵⁵⁶Polytechnic Institute of Porto, Porto, Portugal. ⁵⁵⁷Utrecht University, Utrecht, The Netherlands. ⁵⁵⁸University Medical Center Utrecht, Utrecht, The Netherlands. ⁵⁵⁹National Research Council, Pisa, Italy. ⁵⁶⁰Universidad Miguel Hernandez, Alicante, Spain. ⁵⁶¹Ministry of Health, Mont Fleuri, Seychelles. ⁵⁶²North Karelian Center for Public Health, Joensuu, Finland. ⁵⁶³University of the Witwatersrand, Johannesburg, South Africa. ⁵⁶⁴Institute for Medical Research, Kuala Lumpur, Malaysia. ⁵⁶⁵Xinjiang Medical University, Urumqi, China. ⁵⁶⁶Shanghai Educational Development Co. Ltd, Shanghai, China. ⁵⁶⁷Paracelsus Medical University, Salzburg, Austria. ⁵⁶⁸St George's, University of London, London, UK. ⁵⁶⁹Universitas Indonesia, Jakarta, Indonesia. ⁵⁷⁰Institute of Food and Nutrition Development of Ministry of Agriculture, Beijing, China. ⁵⁷¹Children's Hospital of Fudan University, Shanghai, China. ⁵⁷²University of Cyprus, Nicosia, Cyprus. ⁵⁷³Iran University of Medical Sciences, Tehran, Iran. ⁵⁷⁴West Kazakhstan State Medical University, Aktobe, Kazakhstan. ⁵⁷⁵Inner Mongolia Medical University, Hohhot, China. ⁵⁷⁶Deceased: Deepak N. Amarapurkar, Konrad Jamrozik, Dimitrios Trichopoulos. *e-mail: majid.ezzati@imperial.ac.uk