



OPEN

Mapping local patterns of childhood overweight and wasting in low- and middle-income countries between 2000 and 2017

LBD Double Burden of Malnutrition Collaborators*

A double burden of malnutrition occurs when individuals, household members or communities experience both undernutrition and overweight. Here, we show geospatial estimates of overweight and wasting prevalence among children under 5 years of age in 105 low- and middle-income countries (LMICs) from 2000 to 2017 and aggregate these to policy-relevant administrative units. Wasting decreased overall across LMICs between 2000 and 2017, from 8.4% (62.3 (55.1–70.8) million) to 6.4% (58.3 (47.6–70.7) million), but is predicted to remain above the World Health Organization's Global Nutrition Target of <5% in over half of LMICs by 2025. Prevalence of overweight increased from 5.2% (30 (22.8–38.5) million) in 2000 to 6.0% (55.5 (44.8–67.9) million) children aged under 5 years in 2017. Areas most affected by double burden of malnutrition were located in Indonesia, Thailand, southeastern China, Botswana, Cameroon and central Nigeria. Our estimates provide a new perspective to researchers, policy makers and public health agencies in their efforts to address this global childhood syndemic.

The profound impacts of childhood malnutrition, including both undernutrition and overweight, affect the economic, social and medical well-being of individuals, families, communities and nations^{1,2}. Undernutrition has been the most common form of malnutrition in LMICs³, but as populations experience economic growth, urbanization and demographic change, overweight is an emerging problem, leading to a double burden of malnutrition (DBM). DBM may be manifested at the individual level as stunting in childhood followed by overweight in adulthood⁴. At the household level, research has focused on maternal and child indicators of malnutrition, whereas at the population level, prevalence of both undernutrition with overweight has been reported⁵. In children, DBM can be defined using different combinations of the various indicators of undernutrition (wasting and/or stunting) and overweight, obesity and diet-related noncommunicable diseases (NCDs)⁶. While the most studied type of double burden is that of stunting and obesity, it is mostly applicable at the individual level among overweight adults who were previously stunted from chronic undernutrition during childhood. Wasting is associated with high rate of child mortality, whereas stunting has significant negative impact across the life course and is highly predictive of economic outcomes⁷. Public health nutrition programs designed to address undernutrition may exacerbate overweight⁸, thus a comprehensive understanding of DBM at the population level is crucial for the design of effective interventions.

Our aim was to determine the prevalence of overweight among children under 5 years old in LMICs ($N=105$) for policy-relevant administrative units (district, state, and national level) and determine DBM by combining these estimates with those of wasting prevalence. As there is no broad consensus on the preferred international child growth standards for assessing overweight and obesity among children under 5 (refs. ^{9,10}), we used weight-for-height above established cutoff points defined by the World Health Organization (WHO). This was to analyze overweight estimates in relation to the Global Nutrition Targets (GNTs), which were developed based on WHO standards. Prevalence of early childhood overweight

(including obesity) is defined as the proportion of children under 5 with a weight-for-height z score (WHZ) more than two standard deviations (s.d.) above the WHO sex- and age-specific median growth reference standards¹⁰. This is different from the definition for children between the ages of 5–18 years, which is above one s.d. for overweight and above two s.d. for obese. We selected wasting as the comparative indicator against overweight, as both share recommended population prevalence ranges, which can be used to create bivariate categories for DBM. Child wasting prevalence is defined as the proportion of children under 5 with a WHZ more than two s.d. below the median WHO growth standards¹⁰. Using WHZs allowed modeling of the three categories in the same distribution and thus enabled us to reliably determine the relative proportions for each category using an ordinal approach. Based on WHO and United Nations Children's Fund (UNICEF)-defined thresholds, a moderate level of separate or dual conditions is defined as >5–10%, a high level as >10–15% and a very high level as >15% estimated prevalence¹¹. Finally, we have defined DBM in this study as the simultaneous occurrence of >5% estimated prevalence for both wasting and overweight within the same locations in the same year.

Reversing the rise in childhood overweight is indicated in the United Nations (UN) Sustainable Development Goal 2.2 (ref. ¹²) and WHO's GNTs to improve maternal, infant and young child nutrition¹³. WHO has also set an international target to reduce wasting to <5% by 2025 (ref. ¹⁴). Quantifying changes in childhood overweight and wasting prevalence can be used to measure progress toward these targets, while identifying locales with simultaneous overweight and wasting will better inform intervention planning. In addition, mapping changes in DBM prevalence will provide a deeper understanding of the impact of past intervention strategies, including insight into overweight in children under 5.

Global and local variation in malnutrition trends

Globally in 2017, an estimated 38.3 million (5.6%) children under 5 were overweight and 50.5 million (7.5%) were wasted¹⁵. The majority (91%) of children under 5 affected by wasting and nearly half

*A list of authors and their affiliations appears online. ✉e-mail: sihay@uw.edu

(48%) of overweight children lived in LMICs, with Africa and Asia accounting for the largest shares of the global burden (25% and 46% of overweight and 27% and 69% of wasted children, respectively)¹⁶. Direct comparisons of population-level trends of childhood overweight and wasting generally provide regional- or country-level estimates^{5,16–20}, potentially masking important subnational differences. Previously, we mapped 2000–2017 prevalence and trends in wasting, stunting and underweight among children under 5 across LMICs²¹ using Bayesian model-based geostatistical techniques²². Building from this approach and using data from 420 household surveys representing more than 3 million children, we mapped the relative burdens of overweight and wasting among children under 5 in 105 LMICs from 2000 to 2017. Mapping with a continuous model allows us to incorporate geolocated data and covariates and produce gridded cell-level estimates that can be aggregated to intervention- or policy-relevant geographical areas as boundaries change over time. We present estimates at this local grid cell-level and aggregate to first administrative (such as states and provinces), second administrative (such as districts and departments) and national levels. On the basis of 2000 to 2017 weighted annualized rates of change (AROC), which apply more weight to recent data, we predict prevalence of overweight and wasting and estimate their double burden in 2025. The full array of outputs are available at the Global Health Data Exchange (<http://ghdx.healthdata.org/record/ihme-data/lmic-double-burden-of-malnutrition-geospatial-estimates-2000-2017>) and can be further explored with our customized visualization tools (<https://vizhub.healthdata.org/lbd/dbm>).

Prevalence and trends in early childhood overweight

Across LMICs, the prevalence of early childhood overweight increased from 5.2% (95% uncertainty interval, 4.5–5.4%) to 6.0% (4.8–6.1%) in the modeled study period. Between 2000 and 2017, there were noticeable differences in estimated levels by area (Fig. 1a,b). Although levels varied broadly across LMICs, every modeling region had areas with high estimated prevalence in 2017 (Fig. 1b and Extended Data Fig. 1). These included large contiguous areas across most Central American, Caribbean and South American countries and areas with $\geq 15\%$ estimated prevalence in central Cuba, southern Panama, western Paraguay, scattered throughout several eastern Brazilian states (for example, in Rio Grande do Sul, Minas Gerais, Santa Catarina, Paraná and São Paulo) and Peru's coastal cities of Tacna, Ilo, Islay, Callao, Trujillo and Lima. In Africa, most countries bordering the Sahel had low overweight prevalence (0–5%); areas with $>15\%$ estimated prevalence were concentrated in North Africa throughout Morocco, Algeria, Tunisia, Egypt and select areas of Libya, as well as along South Africa's southern coast and in pockets in Botswana and Zambia. Large areas in eastern and northern China and throughout Mongolia had an estimated overweight prevalence $>15\%$. Countries in the Oceania region had moderate to high levels, with estimates over 15%, such as in Indonesia's Jakarta Pusat and Jakarta Barat regencies (in Jakarta Raya; 17.7% (15.3–18.4%)). The North Africa, Central Asia and Southeast Asia regions showed vast differences across nations; for example, Afghanistan, Sudan and Laos had $<5\%$ estimated national prevalence, whereas Egypt, Uzbekistan, Morocco, Kyrgyzstan and Thailand had $\geq 15\%$. South Asia's estimated levels ranged from $<5\%$ in Bangladesh to $\geq 10\%$ Bhutan. Estimated prevalence in Karbala city in Karbala, Iraq, increased from 13.6% (12.4–14.1%) in 2000 to 29.3% (22.9–29.1%) in 2017. Thailand's southern areas experienced large increases in estimated prevalence levels; Sathorn district, Bangkok Metropolis, had 24.1% (20.1–24.8%) overweight in 2000 and 33.9% (27.5–35.5%) in 2017. Areas with the greatest decrease included Churcampa district, Huancavelica, Peru, decreasing from 17.5% (17.4–17.6%) in 2000 to 10.3% (10.2–10.4%) in 2017. Similarly, overweight in Al Gash district, Kassala, Sudan, declined from 14.1% (13.6–14.5%) to 6.1% (5.2–6.2%).

Within-country differences in estimated overweight levels were found in 37 (35.2%) LMICs, including South Africa, Peru and Indonesia, which had twofold differences in estimated prevalence across second administrative units in 2017. South Africa had high estimated national levels (24.9% (23.9–25.2%)); however, the province of Northern Cape had moderate levels (14.6% (13.6–14.9%)), whereas the southeastern province of Eastern Cape had very high levels (32.7% (30.8–33.9%)). Disparities were further pronounced at the district level. Siyanda (Northern Cape) had 12.5% (11.6–12.9%) prevalence, whereas Ugu (KwaZulu-Natal) had 36.7% (34.0–38.2%). Nearly every modeling region had areas with overweight prevalence that ranked among the highest decile in 2000, 2017 or both years (Fig. 1c).

Overall, the number of overweight children under 5 in LMICs also showed a significant increase from 30.0 million (22.8–38.5) to 55.5 million (44.8–67.9) in the study period (Fig. 2a,b). By 2017, 26.2 million (24.1–27.2 million; 36.0%) of those affected lived in eastern Asia, northern Africa or South America. An estimated 8.6% (8.5–9.9%) of first administrative units had fewer than 1,000 overweight children under 5, 47.5% (47.2–49.5%) had 1,000 to $<10,000$, 43.8% (40.6–44.3%) had 10,000 to $<100,000$ and just 3.8% (3.7–3.9%) had 100,000 or more. Some areas, such as northern and central parts of Bolivia, experienced large annualized declines such that their ranking among the highest estimated prevalence decile in 2000 no longer applied in 2017. In contrast, a large area in India, south of the Tropic of Cancer, experienced large annualized increases in overweight; its ranking among the lowest prevalence decile in 2000 was not maintained in 2017. All modeled regions had areas that experienced average annualized increases of $\geq 1\%$ in overweight prevalence (Fig. 2c). Unless current trajectories change, prevalence of overweight will continue to increase to 2025 (Fig. 2d).

Prevalence and trends in child wasting

The estimated prevalence of early childhood wasting decreased overall across LMICs between 2000–2017, from 8.4% (7.9–9.9%) to 6.4% (4.9–7.9%). The most notable relative reductions were seen across North Africa and in select countries in sub-Saharan African (SSA) regions, Central and Andean America and Southeast Asia regions. In Burkina Faso's Ganzourgou district, estimated levels declined from 20.2% (19.1–21.3%) in 2000 to 11.6% (10.9–12.1%) in 2017, in Yemen's Ash Shaikh Outhman district from 25.1% (22.2–26.3%) to 21.3% (18.9–22.2%) and in Sudan's Al Mahagil district from 31.9% (31.4–32.6%) to 12.2% (10.5–12.9%). Increases in estimated prevalence also occurred, such as in Pakistan's Makran district (Baluchistan), from 7.4% (6.7–7.6%) to 11.4% (10.4–11.8%).

In 2017, there were several instances of contrasting geographic patterns of child wasting compared to those of overweight. Many Central American, Caribbean and South American countries (46%; 11 of 24) affected by overweight ($>15\%$ prevalence) met the WHO GNTs for $<5\%$ prevalence of wasting across all districts based on estimated prevalence (Fig. 3a,b and Extended Data Fig. 2). Estimated wasting prevalence was $\geq 15\%$ in 31.9% (850 of 2,661) and $\geq 20\%$ in 12.9% (342) of second administrative units across Central and South Asian countries, contributing to high prevalence at the national level in India (15.7% (15.4–15.9%)), Pakistan (12.2% (11.8–12.4%)) and Sri Lanka (11.2% (10.5–11.5%)); Afghanistan and Bangladesh maintained high levels (estimated prevalence $\geq 10\%$) across many areas. Local-level estimates delineate very high wasting prevalence ($\geq 15\%$) along the African Sahel from Mauritania to Sudan, in the northeastern Horn of Africa and neighboring countries of Eritrea, Ethiopia, Somalia, Kenya, South Sudan and Yemen, in select areas in Algeria and Egypt, and across Madagascar. In the Middle East, Syria exceeded 15% estimated prevalence throughout most areas and Iraq's southeastern districts exceeded 10%. Estimated levels of wasting were relatively uniform and low across East Asia, with the exception of a few focal areas exceeding 10% or 20% in central

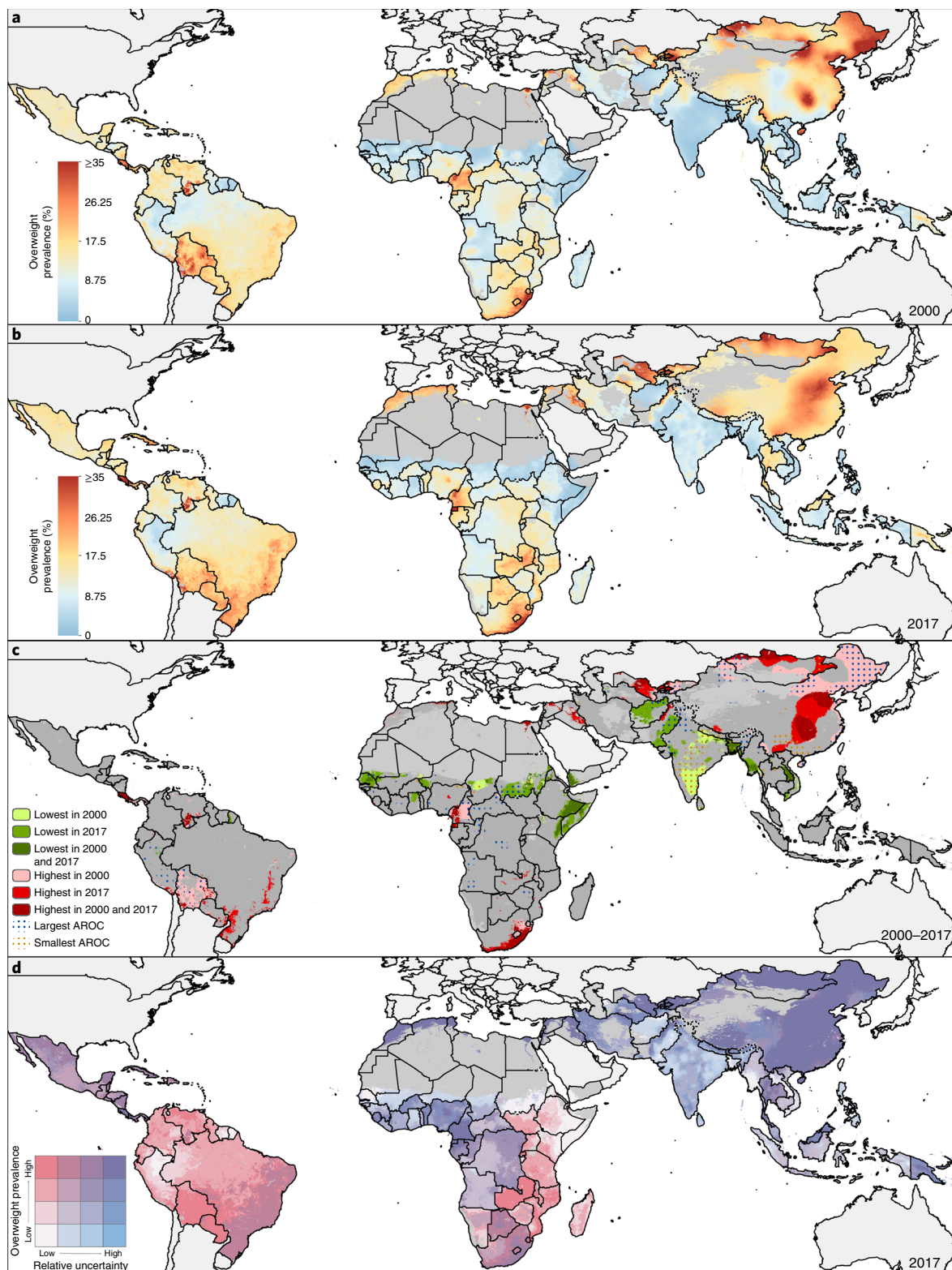


Fig. 1 | Prevalence of overweight children under 5 in LMICs (2000–2017). **a, b**, Prevalence of overweight among children under 5 at 5 × 5-km resolution in 2000 (**a**) and 2017 (**b**). **c**, Overlapping population-weighted lowest and highest 10% of grid cells and AROC in overweight from 2000 to 2017. **d**, Overlapping population-weighted quartiles of overweight and relative 95% uncertainty in 2017. Maps reflect administrative boundaries, land cover, lakes and population; gray colored areas have grid cells classified as ‘barren or sparsely vegetated’ and had fewer than ten people per 1 × 1-km grid cell in 2017 or were not included in this analysis^{39–45}. Maps were generated using ArcGIS Desktop 10.6.

pockets of east China. Most areas in Southeast Asia and Oceania experienced moderate-to-high estimated wasting levels (~10%), whereas some areas in Indonesia’s southern-most islands in Nusa

Tenggara (Timor state) exceeded 15% prevalence. Meanwhile, some areas in Myanmar, Thailand, northern Laos and Vietnam had very low levels, approaching the WHO GNTs.

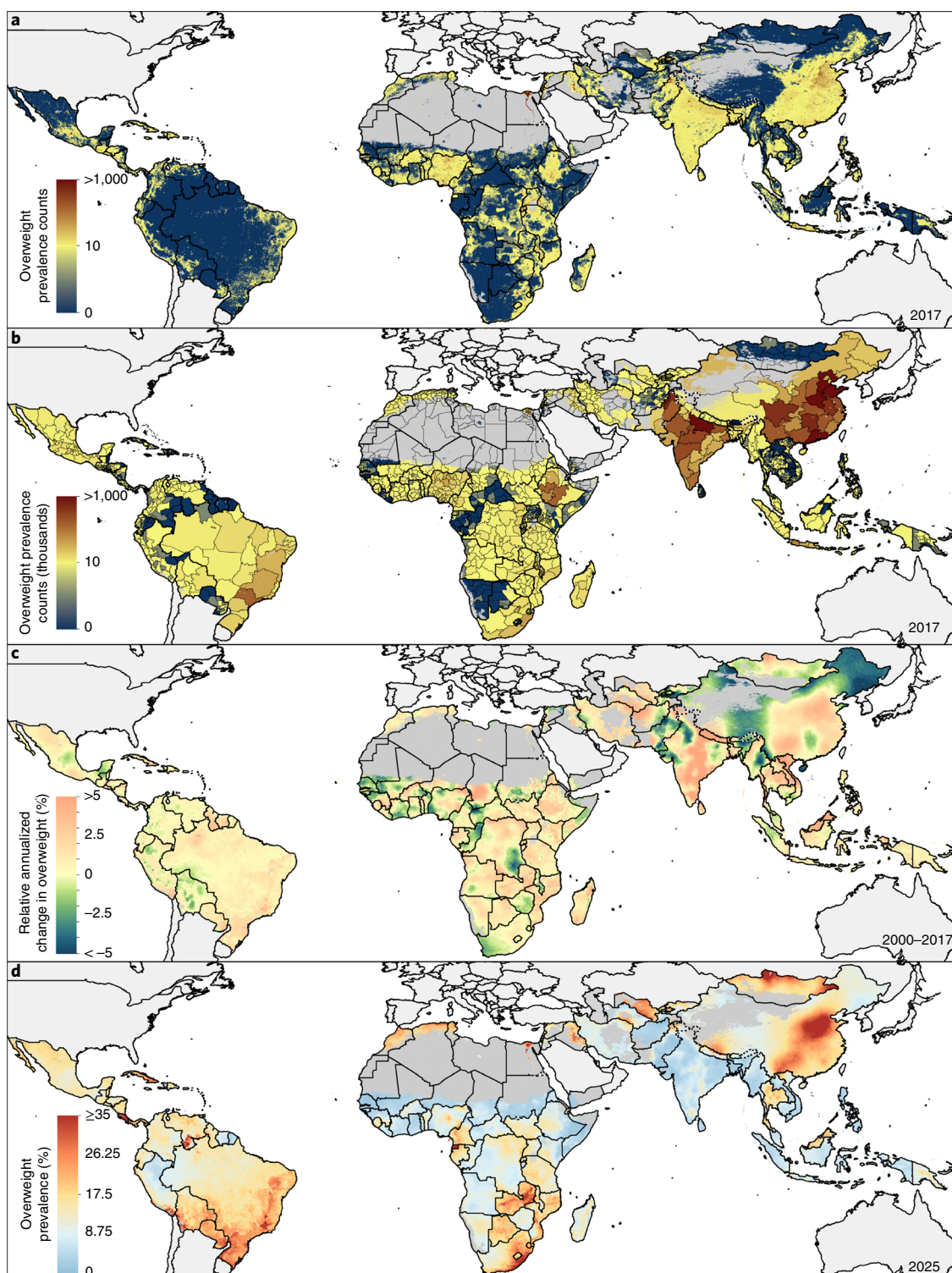


Fig. 2 | Number of overweight children under 5 in LMICs (2000–2017) and progress toward 2025. a,b, Number of children under 5 affected by overweight at a 5 × 5-km resolution (**a**) and by first administrative units (**b**). **c**, Annualized decrease (AD) in overweight prevalence from 2000 to 2017. **d**, Grid cell-level predicted overweight prevalence in 2025 based on AD achieved from 2000 to 2017 and projected from 2017. Maps reflect administrative boundaries, land cover, lakes and population; gray colored areas have grid cells classified as ‘barren or sparsely vegetated’ and had fewer than ten people per 1 × 1-km grid cell in 2017 or were not included in this analysis^{39–45}. Maps were generated using ArcGIS Desktop 10.6.

Between 2000 and 2017, the number of children under 5 affected by wasting decreased from 62.3 (55.1–70.8) million to 58.3 (47.6–70.7) million, 28.4% (28.2–28.5) of whom were in Africa and 65.4% (63.6–67.3) in South Asia in 2017 (Fig. 3c,d). Despite maintaining high estimated prevalence in many areas, all regions

in Africa had areas that experienced among the highest rates of annualized declines in 2000–2017; only a few areas in Chad, Sudan, South Sudan, Ethiopia and Kenya were among the highest decile of estimated prevalence levels in both 2000 and 2017 (Fig. 4a,b). Progress differed across and within African countries, with some

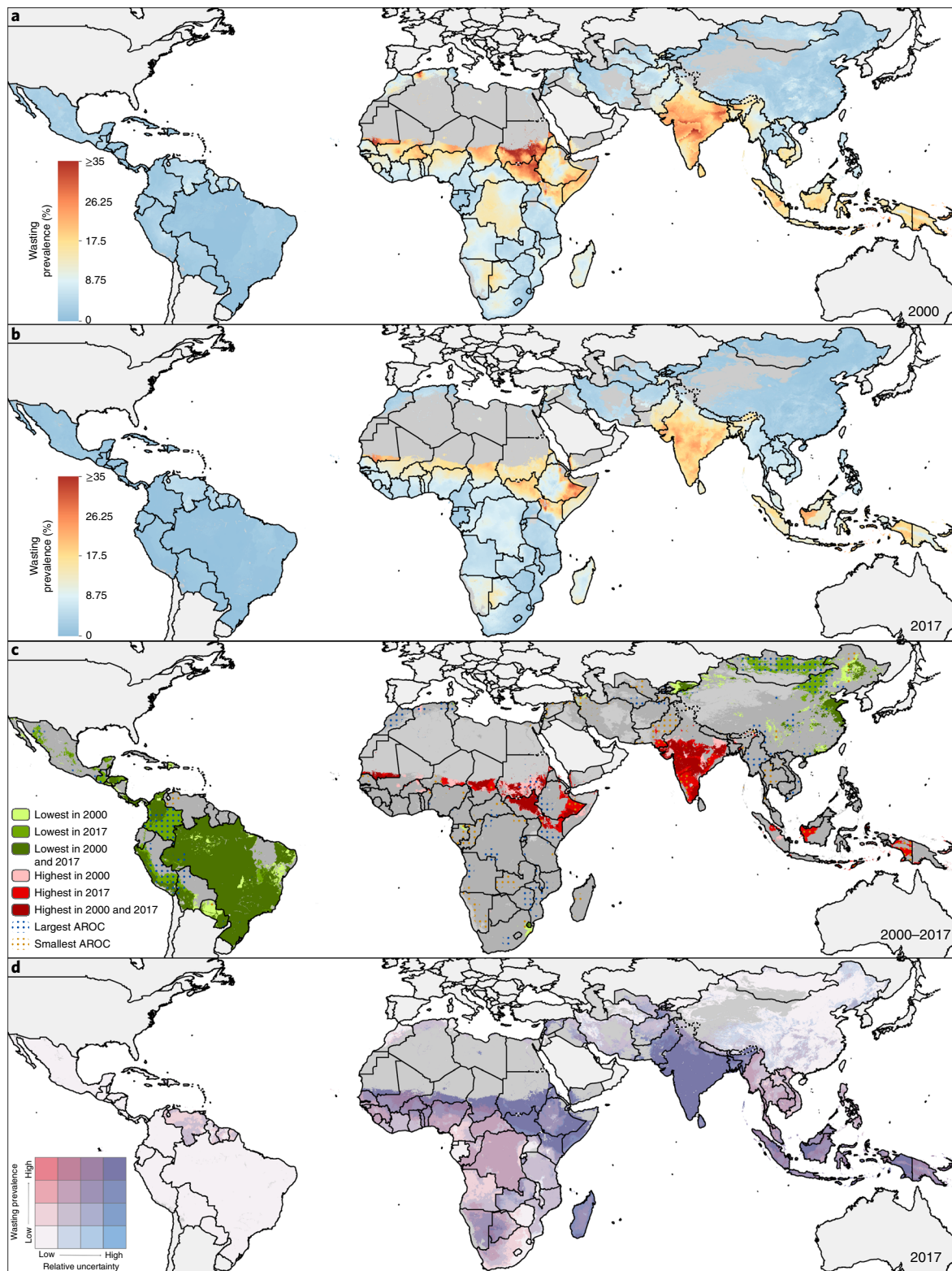


Fig. 3 | Prevalence of wasted children under 5 in LMICs (2000–2017). **a–c**, Prevalence of moderate and severe wasting among children under 5 at a 5×5-km resolution in 2000 (**a**) and 2017 (**b**). **c**, Overlapping population-weighted lowest and highest 10% of grid cells and AROC in wasting from 2000 to 2017. **d**, Overlapping population-weighted quartiles of wasting and relative 95% uncertainty in 2017. Maps reflect administrative boundaries, land cover, lakes and population; gray colored areas have grid cells classified as ‘barren or sparsely vegetated’ and had fewer than ten people per 1×1-km grid cell in 2017 or were not included in this analysis^{39–45}. Maps were generated using ArcGIS Desktop 10.6.

nations, such as Nigeria, Ethiopia and Namibia, experiencing both annualized decreases and increases in wasting within their borders (Fig. 4c). Overall, South America and South SSA demonstrated

the largest annualized declines ($\geq 5\%$) across most of their areas and regions of Latin America and the Caribbean, the Middle East, South Asia, Southeast Asia and Oceania experienced mostly

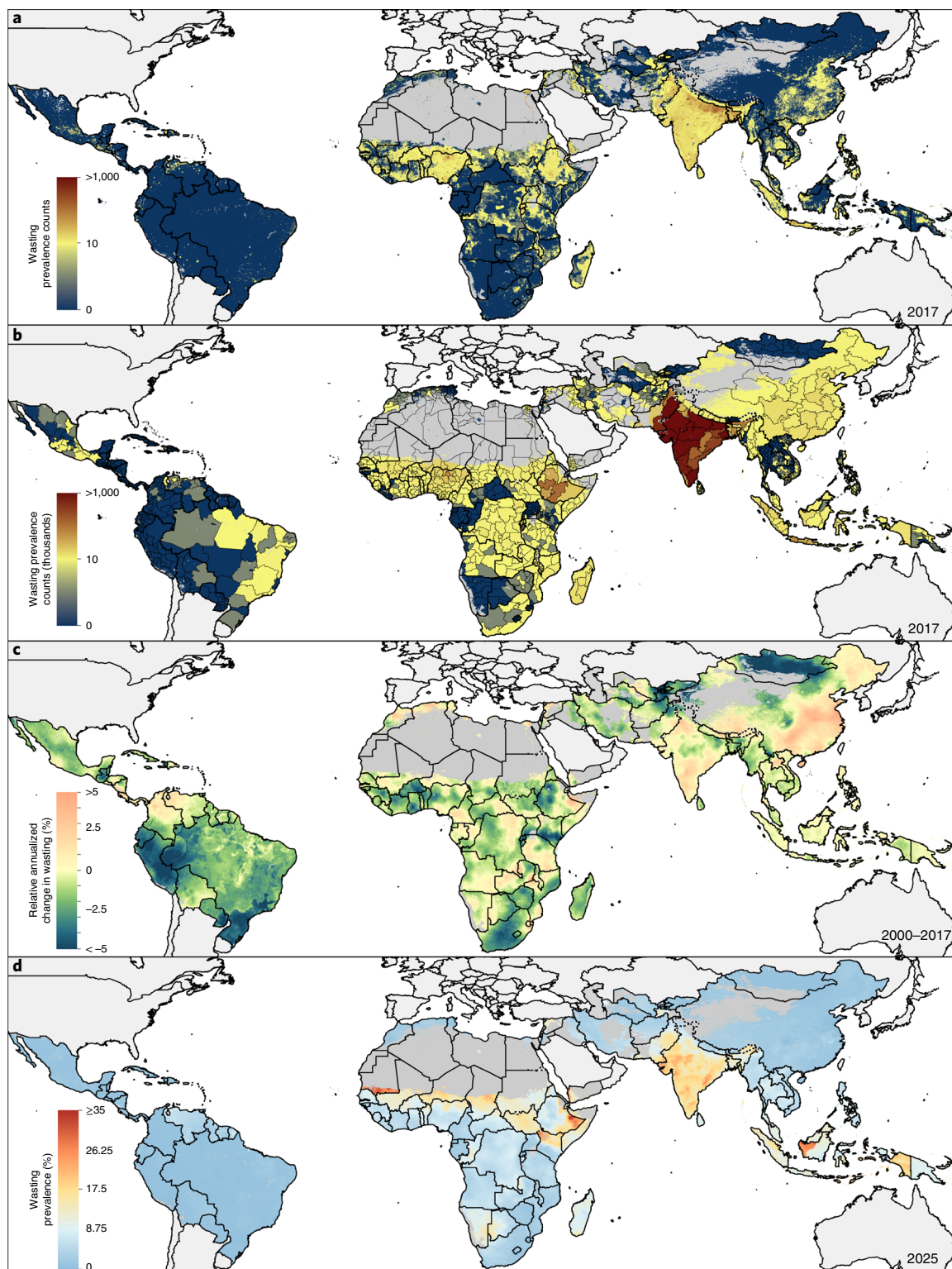


Fig. 4 | Number of wasted children under 5 in LMICs (2000–2017) and progress toward 2025. a,b, Number of children under 5 affected by wasting at the 5 × 5-km resolution (**a**) and by first administrative units (**b**). **c**, AD in wasting prevalence from 2000 to 2017. **d**, Grid cell-level predicted stunting prevalence in 2025 based on AD achieved from 2000 to 2017 and projected from 2017. Maps reflect administrative boundaries, land cover, lakes and population; gray colored areas have grid cells classified as ‘barren or sparsely vegetated’ and had fewer than ten people per 1 × 1-km grid cell in 2017 or were not included in this analysis^{39–45}. Maps were generated using ArcGIS Desktop 10.6.

annualized increases. Large areas of India and parts of central Pakistan experienced some of the highest prevalence levels throughout the study period, as well as annualized increases. Nearly all South Asian countries had large contiguous areas of stagnation or

annualized increases in wasting; given recent rates of progress, few will meet the WHO GNTs in all their locations by 2025 (Fig. 4d). By 2025, 68 (64.8%) of LMICs are predicted to fail to meet the <5% target nationally, all of which are in Africa, Asia and the Middle East.

Based on subnational estimates, 88 (83.8%) and 94 (89.5%) will fail to meet the wasting WHO GNTs in all first and second administrative units, respectively.

Double burden of wasting and overweight

Nearly every modeling region had subnational areas with at least moderate co-occurrence of wasting and overweight ($\geq 5\%$ estimated prevalence of both conditions) in 2017 (Fig. 5 and Extended Data Fig. 3). Exceptions were Central and South America, where Guyana was the only example of moderate DBM (5%–10% of both conditions). In Africa, much of the Democratic Republic of the Congo, Cameroon, Republic of Congo, Zambia and southern Botswana demonstrated high DBM ($\geq 10\%$ of both overweight and wasting). Areas in central Morocco reached some of the highest levels of DBM ($\geq 15\%$ overweight, 10–15% wasting), whereas much of the rest of North Africa had high estimated overweight (10–15%) and moderate estimated wasting (5–10%). Locations scattered throughout Iraq, India and in Southeast Asia mostly experienced moderate wasting (such as Myanmar at 5–10%) or moderate DBM (such as Indonesia at 5–10%), reaching moderate-to-high DBM levels in select areas (such as central Papua New Guinea and Cambodia at 5–10% overweight, 10–15% wasting; Thailand, 10–15% overweight, 5–10% wasting). Relatively rare in East Asia, DBM was at moderate levels at most (5–10% both conditions), such as in provinces in southeastern China. At the national level, 25.7% (27 of 105) LMICs were moderately affected and 5.7% (6 of 105) were highly affected by both overweight and wasting ($\geq 5\%$ and $\geq 10\%$ prevalence of both conditions, respectively). Subnationally, however, 70.5% (74 of 105) of LMICs had moderately affected districts, 11.4% (12 of 105) had highly affected districts and 2.9% (3 of 105) had districts with very high DBM ($\geq 5\%$, $\geq 10\%$ and $\geq 15\%$ prevalence of both conditions, respectively).

Although childhood nutritional status generally improved over 2000–2017, subnational variation in childhood overweight, wasting and DBM was apparent. Declines in wasting and overweight prevalence in South Africa's western areas led to a decrease in DBM prevalence, from high levels in Siyanda district in 2005 (10–15% estimated wasting and overweight) to moderate levels in 2017 (5–10% both conditions); overweight remains very high, however, on the southern coast ($\geq 15\%$). On the basis of annualized trends, 25.7% (27 of 105) of LMICs are predicted to have districts with at least moderate DBM by 2025 and 34.3% (36 of 105) are predicted to have high DBM districts (Fig. 5). Between 2000 and 2017, 8.6% (9 of 105) of LMICs had first administrative units that experienced transition from high estimated prevalence of wasting ($\geq 10\%$) to normal weight ($< 5\%$ both wasting and overweight). Nearly one-third, 32.3% (34 of 105) of LMICs had first administrative units that transitioned from normal weight to high overweight and 7.6% (8 of 105) transitioned from high wasting to high DBM.

Discussion

This study provides overweight estimates and combines them with wasting estimates to highlight DBM across LMICs at a fine geospatial scale. This enables efficient targeting of local-level interventions to improve nutrition outcomes in vulnerable populations. The figures presented here, as well as our online visualization tools, allow for comparing overweight and wasting levels and trends across and within countries for each year from 2000 to 2017, leveraging the spatially resolved underlying data and covariates to produce detailed spatial estimates across all modeled regions. Our estimates show the global trend in early childhood wasting is declining, but areas with high prevalence and little progress, such as in the Sahel and South Asia, remain. Meanwhile, childhood overweight prevalence has increased, especially in tropical South America and regions in the Middle East, Central Asia and Africa.

Across LMICs, trends in childhood overweight have increased while wasting decreased by different magnitudes from 2000–2017, leading to the emergence of DBM in several areas. As countries experience economic growth, they may undergo nutritional transitions wherein the challenges of undernutrition are replaced by those of overweight or the co-occurrence of both conditions⁴. Overall, food security has improved across LMICs in the past decade, which has led to increased availability of calories at the population level²³. Although overweight is a reflection of excess calorie intake and reduced energy expenditure, there is a growing recognition that at the root of the rising rates of overweight are complex interactions between societal, environmental, food industry and individual factors, including biological, psychological and economical factors²⁴. Understanding the factors underpinning these trends is key to predicting how nutrition programs can accelerate amelioration of wasting without incurring high rates of childhood overweight.

Although we included urbanicity as a covariate in our models, we were unable to reliably stratify our results by urban and rural areas. Urbanization is widely viewed as a key driver of the rise in overweight, but an increase in rural body mass index has recently been recognized as a main driver of the global epidemic of obesity in adults²⁵. Such an analysis would thus add important context to our estimates. Case studies in China, Egypt, India, Mexico, the Philippines and South Africa have demonstrated a consistent trend of increased energy content of diets²⁶. Relatively rural areas in China have experienced an increase in the intake of animal source foods and edible oils, likely due to the decreasing cost of these products. Further, increased use of motor vehicles and labor-saving technologies in agriculture have caused a decrease in energy expenditure in all these countries. In Brazil, household consumption of high-calorie ultra-processed foods has steadily replaced that of fresh or minimally processed foods²⁷. Nutritious diets consisting of the latter can help prevent both wasting and stunting, thus work is needed to identify how dietary patterns differ between wasted and overweight children and the underlying factors causing those differences. Widespread collection and assembly of nutrition data from older children and adults would also contribute to a more complete understanding of longitudinal nutrition patterns.

In addition to tracking progress, child nutrition measurements are important for predicting and averting morbidity and mortality. Wasting is often indicative of short-term weight loss due to food shortages, famine or diseases such as diarrhoea^{28–30} and puts children at greater risk of succumbing to common infections²⁸. Childhood overweight is likely to progress into adulthood and is associated with NCDs²⁴, including cardiovascular disease, type 2 diabetes, sleep apnea and cancer^{31,32}. Routine monitoring and reporting of child nutrition status can highlight trends and act as an early warning for health systems, particularly in the context of epidemiological transitions⁴.

Although overall spending on development assistance and investments to address malnutrition from government donors have remained steady, those from multilateral institutions have increased since 2013, amounting to US\$856 million in overseas development assistance in 2016 (ref. 15). These investments, however, fall short of the estimated US\$3.5 trillion per year that malnutrition costs society, US\$500 billion of which is attributable to overweight and obesity³³. By focusing on prevention and early action, healthcare costs can be reduced and human capital increased. One difficulty, however, is addressing the different forms of malnutrition in tandem. Multiple forms of malnutrition are the new normal, according to the GNR¹⁵ and Scaling Up Nutrition^{34,35}. Double-duty actions that could simultaneously combat undernutrition, overweight, obesity, and diet-related NCDs have been proposed to address this problem^{36–38}. Despite progress in identifying such actions, such as the promotion of breastfeeding, double-duty approaches have not been widely adopted. To better respond to the diverse and rapidly

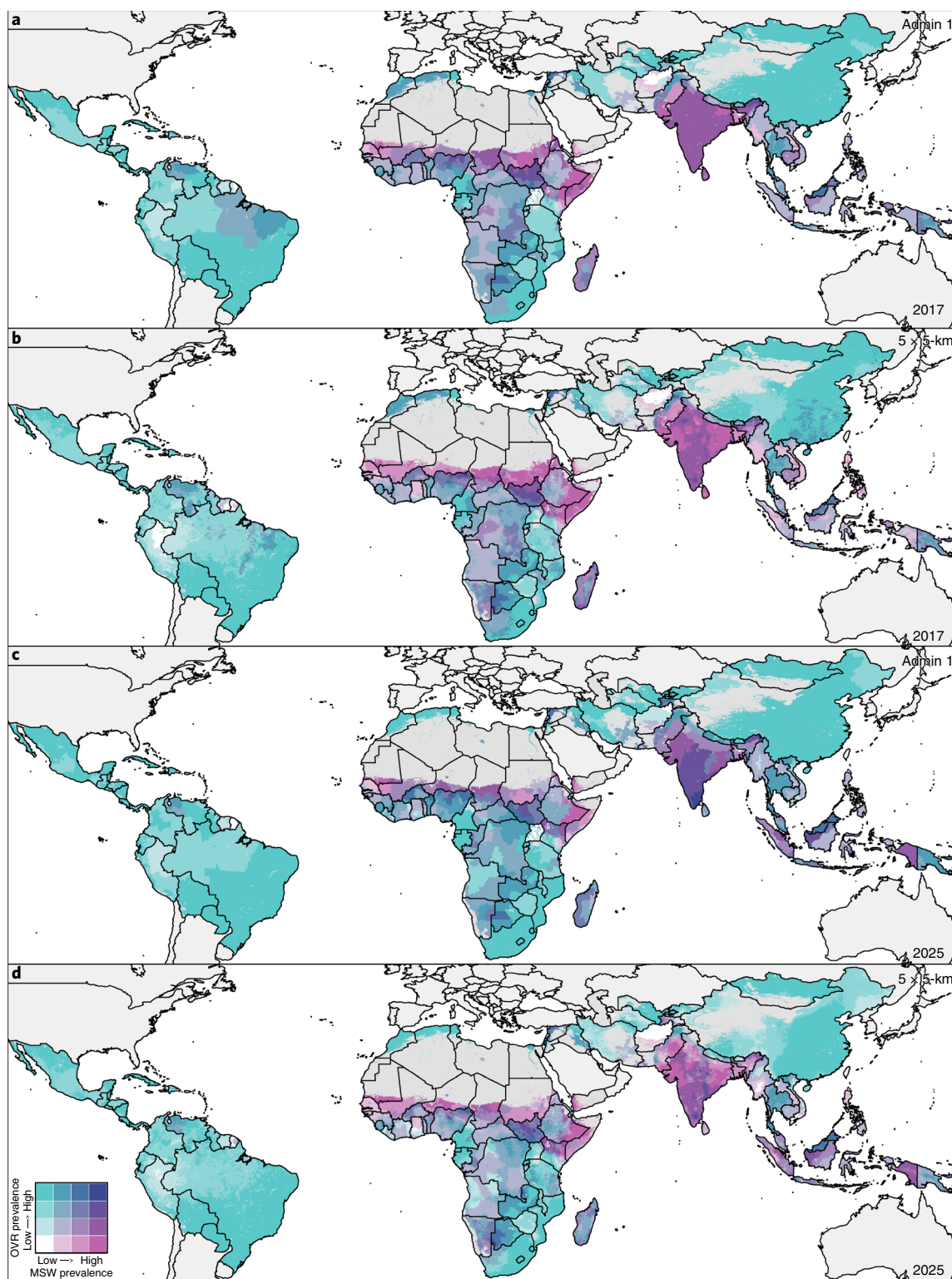


Fig. 5 | Overlapping population-weighted quartiles of overweight and wasting prevalence in children under 5 across LMICs in 2017 and 2025.

a-d, Prevalence of moderate-to-severe overweight (OVR) and wasting (MSW) among children under 5 years of age in 2017 at the first administrative unit (**a**) and at a 5 × 5-km resolution (**b**). **c,d**, Estimated prevalence of moderate to severe OVR and MSW among children under 5 years of age in 2025 at the first administrative unit (**c**) and at a 5 × 5-km resolution (**d**). Quartile cutoffs were 0–5%, ≥5–10%, ≥10–15% and ≥15%. Maps reflect administrative boundaries, land cover, lakes and population; gray colored areas have grid cells classified as ‘barren or sparsely vegetated’ and had fewer than ten people per 1 × 1-km grid cell in 2017 or were not included in these analyses^{39–45}. Maps were generated using ArcGIS Desktop 10.6.

evolving nutrition challenges facing LMICs, sustainable and health-promoting food systems are needed to slow the development of DBM. Due to the multiple causality of malnutrition, multisector

collaboration is required, including agriculture, trade and industry, environment, communication and education, all working towards policy and intervention coherence^{8,24}.

There are several limitations to these analyses, mainly concerning the quantity and quality of the underlying data in the models, as shown in our uncertainty maps (Figs. 1f and 2f). Missing or improbable values in the primary data may contribute bias in the estimates and thus we have incorporated covariates to improve the estimates in areas where data are sparse. Additionally, differences in measurement techniques between surveys, scale miscalibration or equipment failure and poor training and standardization of measurers may contribute bias. Although our estimates were produced at a high spatial resolution, they were limited to prevalence by area, rather than the co-occurrence of wasting and overweight experienced by the same households or individuals. Additional work is required to identify the immediate and basic causes that lead to both wasting and obesity coexisting in the same geographical areas so that appropriate solutions can be identified. Future studies will consider maternal indicators associated with child nutritional outcomes, such as anemia and examine the co-distribution of overweight and stunting to broaden our assessment. New modeling approaches are currently in development to provide full distributions of height, weight and age, for more complete assessments of DBM using all important indicators of undernutrition.

Commendable gains have been made globally against child malnutrition over the past two decades. Our mapped estimates, however, show that high rates of wasting persist and overweight is increasing among young children in many LMICs. Identifying the causes underlying the presence of wasting or overweight in children living in the same community is necessary to formulate appropriate solutions. The estimates provided by this study can aid in the identification of specific areas where further insight can be gathered and trials of policy interventions administered, ultimately contributing to the UN Decade of Action on Nutrition process of sustained and coherent implementation of policies and programs³⁷.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, 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/s41591-020-0807-6>.

Received: 25 October 2019; Accepted: 20 February 2020;

Published online: 20 April 2020

References

- Ng, M. et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the global burden of disease study 2013. *Lancet* **384**, 766–781 (2014).
- Black, R. E. et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451 (2013).
- Black, R. E. et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* **371**, 243–260 (2008).
- World Health Organization. Double burden of malnutrition <http://www.who.int/nutrition/double-burden-malnutrition/en/> (2018).
- de Onis, M., Blössner, M. & Borghi, E. Global prevalence and trends of overweight and obesity among preschool children. *Am. J. Clin. Nutr.* **92**, 1257–1264 (2010).
- Popkin, B. M., Corvalan, C. & Grummer-Strawn, L. M. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet* **395**, 65–74 (2020).
- UNICEF, WHO & The World Bank. Joint child malnutrition estimates - levels and trends (2017 edition) <https://www.who.int/nutgrowthdb/estimates2016/en/> (2017).
- Hawkes, C., Demaio, A. R. & Branca, F. Double-duty actions for ending malnutrition within a decade. *Lancet Glob. Health* **5**, e745–e746 (2017).
- Cole, T. J., Bellizzi, M. C., Flegal, K. M. & Dietz, W. H. Establishing a standard definition for child overweight and obesity worldwide: international survey. *Brit. Med. J.* **320**, 1240 (2000).
- World Health Organization. Training course on child growth assessment <http://www.who.int/childgrowth/training/en/> (2008).
- de Onis, M. et al. Prevalence thresholds for wasting, overweight and stunting in children under 5 years. *Public Health Nutr.* **22**, 175–179 (2019).
- United Nations. Goal 2: sustainable development knowledge platform <https://sustainabledevelopment.un.org/sdg2>.
- World Health Organization. Global nutrition targets 2025: childhood overweight policy brief http://www.who.int/nutrition/publications/globaltargets2025_policybrief_overweight/en/ (2014).
- World Health Organization. Global nutrition targets 2025: wasting policy brief http://www.who.int/nutrition/publications/globaltargets2025_policybrief_wasting/en/ (2014).
- Development Initiatives. 2018 Global nutrition report: shining a light to spur action on nutrition <https://globalnutritionreport.org/reports/global-nutrition-report-2018/> (2018).
- United Nations Children's Fund, World Health Organization & The World Bank. Levels and trends in child malnutrition: key findings of the 2018 edition <https://www.who.int/nutgrowthdb/2018-jme-brochure.pdf?ua=1> (2018).
- World Health Organization. Data: nutrition - joint child malnutrition estimates (2018 edition) <http://apps.who.int/gho/tableau-public/tpc-frame.jsp?id=402> (2018).
- Tzioumis, E., Kay, M. C., Bentley, M. E. & Adair, L. S. Prevalence and trends in the childhood dual burden of malnutrition in low- and middle-income countries, 1990–2012. *Public Health Nutr.* **19**, 1375–1388 (2016).
- Abarca-Gómez, L. et al. Worldwide trends in body-mass index, underweight, overweight and obesity from 1975 to 2016: a pooled analysis of 2,416 population-based measurement studies in 128.9 million children, adolescents and adults. *Lancet* **390**, 2627–2642 (2017).
- Humbwavali, J. B., Giugliani, C., Silva, I. C. Mda & Duncan, B. B. Temporal trends in the nutritional status of women and children under five years of age in sub-Saharan African countries: ecological study. *Sao Paulo Med. J. Rev. Paul. Med.* **136**, 454–463 (2018).
- Kinyoki, D. K. et al. Mapping child growth failure across low- and middle-income countries. *Nature* **577**, 231–234 (2020).
- Diggle, P. & Ribeiro, P. J. *Model-based Geostatistics* (Springer, 2007); <https://doi.org/10.1007/978-0-387-48536-2>
- FAO, IFAD, UNICEF, WFP & WHO. The State of Food Security and Nutrition in the World 2019. Safeguarding Against Economic Slowdowns and Downturns (FAO, 2019).
- Wells, J. C. et al. The double burden of malnutrition: aetiological pathways and consequences for health. *Lancet* **395**, 75–88 (2020).
- Bixby, H. et al. Rising rural body-mass index is the main driver of the global obesity epidemic in adults. *Nature* **569**, 260–264 (2019).
- Food and Agriculture Organization of the United Nations. The double burden of malnutrition. Case studies from six developing countries. *FAO Food Nutr. Pap.* **84**, 1–334 (2006).
- Monteiro, C. A., Levy, R. B., Claro, R. M., de Castro, I. R. R. & Cannon, G. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. *Public Health Nutr.* **14**, 5–13 (2010).
- Wang, Y. & Chen, H.-J. in *Handbook of Anthropometry* (ed. Preedy, V. R.) 29–48 (Springer, 2012).
- WHO. Physical status: the use and interpretation of anthropometry: report of a WHO Expert Committee http://apps.who.int/iris/bitstream/handle/10665/37003/WHO_TRS_854.pdf;jsessionid=2FE8F4F177D025F6433656F4F7577F3F?sequence=1 (1995).
- Neufeld, L. M. & Osemdar, S. J. M. World nutrition situation: global, regional and country trends in underweight and stunting as indicators of nutrition and health of populations. *Internat. Nutr.* **78**, 11–19 (2013).
- CDC. Causes and consequences of childhood obesity <https://www.cdc.gov/obesity/childhood/causes.html> (2016).
- Ong, K. K. L., Ahmed, M. L., Emmett, P. M., Preece, M. A. & Dunger, D. B. Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. *Brit. Med. J.* **320**, 967 (2000).
- Global Panel on Agriculture and Food Systems for Nutrition. The cost of malnutrition: why policy action is urgent <https://glopan.org/sites/default/files/pictures/CostOfMalnutrition.pdf> (2016).
- Scaling Up Nutrition Civil Society Network. SUN Movement Strategy & Roadmap 2016–2020. http://docs.scalingupnutrition.org/wp-content/uploads/2016/09/SR_20160901_ENG_web_pages.pdf (2016).
- Scaling Up Nutrition (SUN) Movement: Annual Progress Report 2016. https://scalingupnutrition.org/wp-content/uploads/2016/11/SUN_Report_20161129_web_All.pdf (2016).
- Hawkes, C. et al. Double-duty actions: seizing programme and policy opportunities to address malnutrition in all its forms. *Lancet* **395**, 142–155 (2020).
- World Health Organization. United Nations decade of action on nutrition 2016–2025: towards country-specific SMART commitments for action on nutrition <http://www.fao.org/3/a-i6130e.pdf> (2016).
- Nugent, R. et al. Economic effects of the double burden of malnutrition. *Lancet* **395**, 156–165 (2020).

39. Global Administrative Areas. GADM database of global administrative areas <http://www.gadm.org> (2018).
40. Land Processes Distributed Active Archive Center. Combined MODIS 5.1. MCD12Q1 | LP DAAC: NASA Land Data Products and Services. <https://lpdaac.usgs.gov/products/mcd12q1v006/> (2017).
41. Lehner, B. & Döll, P. Development and validation of a global database of lakes, reservoirs and wetlands. *J. Hydrol.* **296**, 1–22 (2004).
42. World Wildlife Fund. Global lakes and wetlands database, level 3 <https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database> (2004).
43. Tatem, A. J. WorldPop, open data for spatial demography. *Sci. Data* **4**, 170004 (2017).
44. WorldPop. WorldPop dataset http://www.worldpop.org.uk/data/get_data/ (2017).
45. GeoNetwork. The Global Administrative Unit Layers (GAUL) <http://www.fao.org/geonetwork/srv/en/main.home> (2015).

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 license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license 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 license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2020

Methods

Overview. Our study follows the Guidelines for Accurate and Transparent Health Estimates Reporting⁴⁸ (Supplementary Table 1). The analyses used model-based geostatistics to generate local-, administrative- and national-level estimates of children under 5 overweight, wasting prevalence and double burden in LMICs over time. Using an ensemble modeling framework that fed into a Bayesian generalized linear mixed-effects model with a correlated space-time random effect and 1,000 draws from an approximate posterior distribution, we generated annual prevalence estimates for overweight and wasting on a 5 × 5-km grid over 105 LMICs from 2000 to 2017 and aggregated these to administrative and national levels (Supplementary Table 2). Countries were selected for inclusion in this study using the socio-demographic index (SDI), a summary measure of development that combines education, fertility and poverty⁴⁷. Selected countries were in the low, lower-middle and middle SDI quintiles, with several exceptions (Supplementary Table 2). China, Libya, Malaysia, Panama and Turkmenistan were included despite higher-middle SDIs for geographic continuity with other included countries. Albania, Bosnia-Herzegovina and Moldova were excluded due to geographic discontinuity and lack of available survey data. We did not conduct estimates for the island nations of American Samoa, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands or Tonga, as no survey data could be sourced.

Data. Surveys and child anthropometry data. We extracted individual-level height, weight and age data for children under 5 from household survey series including the Demographic and Health Surveys, Multiple Indicator Cluster Surveys, Living Standards Measurement Study and Core Welfare Indicators Questionnaire, among other country-specific child health and nutrition surveys^{49–52} (Supplementary Tables 3 and 4). Included in our models were 420 georeferenced household surveys representing over 3 million children under 5. Each individual child record was associated with a cluster, a group of neighboring households or a ‘village’ that acted as a primary sampling unit. Approximately 185 surveys with height, weight and age data included geographic coordinates or precise place names for each cluster within that survey. In the absence of geographic coordinates for each cluster, we assigned data to the smallest available administrative areal unit in the survey (polygon) while accounting for the survey sample design (15,781 survey polygons for overweight and wasting)^{53,54}. Boundary information for these administrative units was obtained as shapefiles either directly from the surveys or by matching to shapefiles in the Global Administrative Unit Layers⁵⁵ database or the Database of Global Administrative Areas⁵⁶. In select cases, shapefiles provided by the survey administrator were used or custom shapefiles were created based on survey documentation. These areal data were resampled to point locations using a population-weighted sampling approach over the relevant areal unit with the number of locations set proportionally to the number of grid cells in the area and the total weights of all the resampled points summing to one⁵⁷.

Select data sources were excluded for the following reasons: missing survey weights for areal data, missing sex or age variable, incomplete sampling (for example, only children ages 0–3 years measured) or untrustworthy data (as determined by the survey administrator or by inspection). Details on the survey data excluded for each country can be found in Supplementary Table 5. Data extraction and processing methods have been described previously²¹.

Child anthropometry. Using height, weight, age and sex data for each individual, WHZs were calculated using the age-, sex- and indicator-specific lambda-mu-sigma values from the 2006 WHO Child Growth Standards^{10,57}. The lambda-mu-sigma methodology allows for Gaussian *z* score calculations and comparisons to be applied to skewed, non-Gaussian distributions⁵⁸. A child was classified as overweight or wasted if their weight-for-height/length was more than two s.d. (*z* scores) above or below the WHO growth reference population, respectively⁵⁹. These individual-level data observations were then collapsed to cluster-level totals for the number of children sampled and total number of children under 5 affected by overweight and the total number of children who are wasted out of the children who were not overweight.

Temporal resolution. We estimated prevalence of overweight and wasting annually from 2000 to 2017 using a model that allowed us to account for data points measured across survey years, and as such, allows us to predict at monthly or finer temporal resolutions. We were limited, however, both computationally and by the temporal resolution of covariates (Supplementary Table 6) and thus produced only annual estimates.

Seasonality adjustment. WHZs were used to calculate individual child wasting status. As a data preprocessing step, we performed a seasonality adjustment on individual-level child weights in order to account for differences in observed child weight that may have been due to food scarcity during the month in which the survey was conducted. To adjust weight measurements, we fitted a model for each region with a 12-month seasonal spline, a country-level fixed effect and a smooth spline over the duration of our data collection using the *mgcv* package in R and the following formula:

$$\text{WHZ} \sim s_{cc}(\text{month}) + s_{ip}(t) + \text{as.factor}(\text{country}).$$

Month is the integer-valued month of the year (1, ..., 12), *t* is the time of the interview in integer months since the earliest observation of any child in the dataset and country is a factor variable representing the country where the observation was recorded. We modeled the periodic component on months using 12 cyclic cubic (*cc*) regression splines basis functions and we accounted for a smooth longer time temporal trend using four thin-plate (*tp*) splines. The country effects and the long-term temporal spline were included only to avoid confounding during fitting of the seasonal spline fit and neither country effects nor the long-term trend was used in the seasonal adjustment. We then adjusted all observations to account for the difference in the seasonal period between the month of the interview and an average day of the year as determined by which days aligned with the mean of the periodic spline.

Spatial covariates. In order to leverage strength from locations with observations to the entire spatial-temporal domain, we compiled several 5 × 5-km raster layers of putative socioeconomic and environmental correlates of malnutrition in the 105 LMICs (Supplementary Table 6). These covariates were selected based on their potential to be predictive for overweight and wasting, according to literature review and plausible hypothesis as to their influence. Acquisition of temporally dynamic datasets, where possible, was prioritized to best match our observations and thus predict the changing dynamics of the two indicators. Of the 12 covariates included, 6 were temporally dynamic and were reformatted as a synoptic mean over each estimation period or as a mid-period year estimate. These included average daily mean rainfall (precipitation), educational attainment in women of reproductive age (15–49 years old), enhanced vegetation index, fertility, urbanicity and population. The remaining six covariate layers were static throughout the study period and were applied uniformly across all modeling years; these covariates included growing season length, irrigation, nutritional yield for vitamin A, nutritional yield for protein, nutritional yield for iron and travel time to nearest settlement >50,000 inhabitants.

To select covariates and capture possible nonlinear effects and complex interactions between them, an ensemble covariate modeling method was implemented⁶⁰. For each region, three submodels were fitted to our dataset, using all of our covariate data as explanatory predictors: generalized additive models, boosted regression trees and lasso regression. Each submodel was fitted using fivefold cross-validation to avoid overfitting and the out-of-sample predictions from across the five holdouts were compiled into a single comprehensive set of out-of-sample predictions from that model. Additionally, the same submodels were also run using 100% of the data and a full set of in-sample predictions were created. The three sets of out-of-sample submodel predictions were fed into the full geostatistical model as the explanatory covariates when performing the model fitting. The in-sample predictions from the submodels were used as covariates when generating predictions using the fitted full geostatistical model. A recent study has shown that this ensemble approach can improve predictive validity by up to 25% over an individual model⁶⁰.

Analysis. Geostatistical model. In this study, wasting was defined as the proportion of children under 5 below negative 2 WHZ (<−2 WHZ); normal category, the proportion of children under 5 between negative 2 and positive 2 WHZ *z* score (>−2 and <2 WHZ); and overweight was defined as the proportion of children under 5 above positive 2 WHZ *z* score (>2 WHZ) as defined in the WHO growth reference population⁵⁹. To model the full distribution of possible indicators of nutritional status in WHZ (wasting (<−2 WHZ), normal (>−2 and <2 WHZ) and overweight (>2 WHZ)), we used an ordinal modeling approach^{61,62} to estimate the relative proportion of each indicator. A similar modeling approach was used to estimate vaccine coverage in Africa⁶³.

We used a continuation ratio model to estimate the prevalence of three categories: wasting, normal weight and overweight. We first modeled the proportion of wasting children within a Bayesian hierarchical framework using logistic regression with a spatially and temporally explicit generalized linear mixed-effects model. Second, we modeled the proportion of the children that were overweight conditioned on not being wasted using the same Bayesian modeling framework. The estimates from the second conditional model were then combined with the wasting estimates to compute the proportion of overweight children in the full distribution.

At each cluster, *j*, where *j* = 1, 2, ..., *n*, and time *t*, where *t* = 2000, 2001, ..., 2017, the prevalence of wasting was modeled using the observed number of children in cluster *d*, who were found to be wasted as a binomial count data C_d among a sample size N_d .

$$\begin{aligned} C_d | p_{i(d),t(d)}, N_d &\sim \text{Binomial}(p_{i(d),t(d)}, N_d) \forall \text{ observe clusters } d \text{ logit}(p_{i,t}) \\ &= \beta_0 + \mathbf{X}_{i,t} \boldsymbol{\beta} + Z_{i,t} + \epsilon_{ctr(i)} + \epsilon_{i,t} + Z_{i,t} \forall i \in \text{spatial domain} \forall t \in \text{time domain} \\ \sum_{h=1}^3 \beta_h &= 1 \\ \epsilon_{ctr} &\sim \text{iid Normal}(0, \gamma^2) \\ \epsilon_{i,t} &\sim \text{iid Normal}(0, \sigma^2) \\ \mathbf{Z} &\sim \text{GP}(0, \Sigma^{\text{space}} \otimes \Sigma^{\text{time}}) \\ \Sigma^{\text{space}} &= \frac{\omega^2}{1 + (\kappa D)^{2\nu}} \times (\kappa D)^\nu \times \mathbf{K}_\nu(\kappa D) \\ \Sigma_{j,k}^{\text{time}} &= \rho^{|k-j|} \end{aligned}$$

For indices d, i and t , $*$ (index) is the value of $*$ at the index. The annual prevalence of wasting, $p_{i,t}$, in cluster i , in time t , was modeled as a linear combination of the three submodels, (generalized additive models, boosted regression trees and lasso regression), rasterized covariate values, $X_{i,t}$, a correlated spatiotemporal random effect term $Z_{i,t}$, country random effects $\epsilon_{ctr(i)}$, with one unstructured country random effect fitted for each country in the modeling region and all ϵ_{ctr} sharing a common variance parameter, γ^2 , and an independent nugget random effect $\epsilon_{i,t}$, with variance parameter, σ^2 . Coefficients β_h in the three submodels $h = 1, 2, 3$ represent their respective predictive weighting in the logit link, while the joint error term $Z_{i,t}$ accounts for residual spatiotemporal autocorrelation between individual data points that remain after accounting for the predictive effect of the submodel covariates, the country-level random effect $\epsilon_{ctr(i)}$ and the nugget, $\epsilon_{i,t}$. The residuals $Z_{i,t}$ were modeled as a three-dimensional Gaussian process in space–time centered at zero and with a covariance matrix constructed from a Kronecker product of spatial and temporal covariance kernels. The spatial covariance, Σ^{space} , was modeled using an isotropic and stationary Matérn function⁶⁴ and temporal covariance, Σ^{time} , as an annual autoregressive (AR1) function over the 18 years represented in the model. In the stationary Matérn function, Γ is the gamma function, K_ν is the modified Bessel function of order $\nu > 0$, $\kappa > 0$ is a scaling parameter, D denotes the Euclidean distance and ω^2 is the marginal variance. The scaling parameter, κ , is defined to be $\kappa = \sqrt{8\nu}/\delta$, where δ is a range parameter (about the distance where the covariance function approaches 0.1) and ν is a scaling constant, which is set to 2 rather than fitted from the data. The number of rows and the number of columns of the spatial Matérn covariance matrix are both equal to the number of spatial mesh points for a given modeling region. The number of rows and the number of columns of the spatial Matérn covariance matrix are both equal to the number of spatial mesh points for a given modeling region. In the AR1 function, ρ is the autocorrelation function and k and j are points in the time series where $|k-j|$ defines the lag. The number of rows and the number of columns of the AR1 covariance matrix are both equal to the number of temporal mesh points (18). The number of rows and the number of columns of the space–time covariance matrix, $\Sigma^{space} \otimes \Sigma^{time}$, for a given modeling region are both equal to the number of spatial mesh points \times the number of temporal mesh points.

This approach leverages the residual correlation structure to more accurately predict prevalence estimates for locations with no data, while also propagating the dependence in the data through to uncertainty estimates⁶⁵. The posterior distributions were fitted using computationally efficient and accurate approximations in R-INLA^{66,67} (integrated nested Laplace approximation) with the stochastic partial differential equations⁶⁸ approximation to the Gaussian process residuals using R project v.3.5.1. The stochastic partial differential equations approach using INLA has been demonstrated elsewhere, including the estimation of health indicators, particulate air matter and population age structure^{69–71}. Uncertainty intervals were generated from 1,000 draws (statistically plausible candidate maps)⁷² created from the posterior-estimated distributions of modeled parameters.

Post estimation. To transform grid cell-level estimates into a range of information useful to a wide constituency of potential users, estimates were aggregated at first and second administrative units specific to each country and at national levels⁷³. Although the models can predict all locations covered by available raster covariates, all final model outputs for which land cover was classified as ‘barren or sparsely vegetated’ on the basis of Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data (2013) were masked⁷⁴. Areas where the total population density was less than ten individuals per 1×1 -km grid cell in 2015 were also masked in the final outputs.

Model validation. Models were validated using spatially stratified fivefold out-of-sample cross-validation. In order to offer a more stringent analysis by accounting for some of the spatial correlation in the data, holdout folds were created by combining sets of all data falling with first administrative level areas. Validation was performed by calculating bias (mean error), variance (root-mean-square error), 95% data coverage within prediction intervals and correlation between observed data and predictions. All validation metrics were calculated on the out-of-sample predictions from the fivefold cross-validation. All validation procedures and corresponding results are provided in Supplementary Tables 7–18.

Projections. To compare our estimated rates of improvement in overweight and wasting prevalence over the last 18 years with the improvements needed between 2017 and 2025 to meet WHO GNTs, we performed a simple projection using estimated AROC applied to the final year of our estimates. Both AROC and projections were calculated at the draw-level to obtain the uncertainty of the estimates.

For each indicator i , we calculated AROC at each grid cell (m) by calculating the AROC between each pair of adjacent years t :

$$AROC_{u,m,t} = \text{logit} \left(\frac{p_{u,m,t}}{p_{u,m,t-1}} \right)$$

We then calculated a weighted AROC for each indicator by taking a weighted average across the years, where more recent AROCs were given more weight in the average. We defined the weights to be:

$$W_t = (t - 2000 + 1)^\gamma,$$

where γ may be chosen to give varying amounts of weight across the years. For each indicator, we then calculated the average AROC to be:

$$AROC_{u,m} = \left(\sum_{2001}^{2017} W_t \times AROC_{u,m,t} \right)$$

Finally, we calculated the projections (Proj) by applying the AROC in our 2017 mean prevalence estimates to produce estimates in 8 years from 2017 to 2025.

$$\text{Proj}_{u,m,2025} = \text{logit}^{-1} \left(\text{logit}(p_{u,m,2017}) + AROC_{u,m} \times 8 \right).$$

This projection scheme is analogous to the methods used in the Global Burden of Disease 2017 study¹⁷ for measurement of progress and projected attainment of health-related Sustainable Development Goals. Our projections are based on the assumption that areas will sustain the current AROC, and the precision of the AROC estimates is dependent on the level of uncertainty emanating from the estimation of annual prevalence.

Priors. The following priors were used for our overweight and wasting models:

$$\begin{aligned} \beta_0 &\sim N(\mu = 0, \sigma^2 = 3^2), \\ \beta &\sim \text{iid } N\left(\mu = \frac{1}{\text{no. ensemble models}}, \sigma^2 = 3^2\right), \\ \log\left(\frac{1+\rho}{1-\rho}\right) &\sim N(\mu = 4, \sigma^2 = 1.2^2), \\ \log\left(\frac{1}{\sigma_{\text{nugget}}^2}\right) &\sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}), \\ \log\left(\frac{1}{\sigma_{\text{country}}^2}\right) &\sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}), \\ \theta_1 = \log(\sigma_k^2) &\sim N(\mu_{\theta_1}, \sigma_{\theta_1}^2) \\ \theta_2 = \log(\kappa) &\sim N(\mu_{\theta_2}, \sigma_{\theta_2}^2) \end{aligned}$$

Given that our covariates used in INLA (the predicted outputs from the ensemble models) should be on the same scale as our predictive target, we believe that the intercept in our model should be close to zero and that the regression coefficients should sum to 1. As such, we chose the prior for our intercept to be $N(0, \sigma^2 = 3^2)$ and the prior for the fixed-effect coefficients to be $N\left(\frac{1}{\text{no. ensemble models}}, \sigma^2 = 3^2\right)$. The prior on the temporal correlation parameter, ρ , was chosen to be mean zero, showing no prior preference for either positive or negative autocorrelation structure and with a distribution wide enough such that within three s.d. of the mean, the prior includes values of ρ ranging from -0.95 to 0.95 . The priors on the random effect variances were chosen to be relatively loose given that we believe our fixed-effects covariates should be well correlated with our outcome of interest, which might suggest relatively small random effects values. At the same time, we wanted to avoid using a prior that was so diffuse as to actually put high prior weight on large random effect variances. For stability, we used the uncorrelated multivariate normal priors that INLA automatically determines (based on the finite elements mesh) for the log-transformed spatial hyperparameters κ and τ . In our parameterization, we represent α and γ in the log gamma distribution as shape and inverse-scale, respectively.

Prior sensitivity analysis. Sensitivity analysis was undertaken to assess the impact of the hyper-priors for the nugget, country random effects, and space–time correlation. We considered two different sets of priors related to the nugget and country random effects and three set related to space–time correlation, resulting in six different combinations of hyper-priors as outlined below.

Model 1: In this model, we used the default hyper-priors in INLA⁷⁵ (for both nugget and country random effects. The hyper-prior for the AR1 rho, ρ , was retained as shown below.

$$\begin{aligned} \log\left(\frac{1}{\sigma_{\text{nugget}}^2}\right) &\sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}) \text{ and} \\ \log\left(\frac{1}{\sigma_{\text{country}}^2}\right) &\sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}). \\ \log\left(\frac{1+\rho}{1-\rho}\right) &\sim \text{Normal}(\mu = 4, \sigma^2 = 1.2^2) \end{aligned}$$

Model 2: The hyper-priors for nugget were changed as indicated below, where hyper-priors for country random effect were the default hyper-priors in INLA. The hyper-priors for the AR1 rho, ρ , were retained the same as model 1.

$$\begin{aligned} \log\left(\frac{1}{\sigma_{\text{nugget}}^2}\right) &\sim \text{loggamma}(\alpha = 1, \gamma = 2) \text{ and} \\ \log\left(\frac{1}{\sigma_{\text{country}}^2}\right) &\sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}). \\ \log\left(\frac{1+\rho}{1-\rho}\right) &\sim \text{Normal}(\mu = 4, \sigma^2 = 1.2^2) \end{aligned}$$

Model 3: In this model the hyper-priors for country random effects and nugget were exchanged, where hyper-priors for nugget were the default hyper-priors in INLA. The hyper-priors for the AR1 rho, ρ , were retained the same as model 1.

$$\log\left(\frac{1}{\sigma_{\text{nug}}^2}\right) \sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}) \text{ and}$$

$$\log\left(\frac{1}{\sigma_{\text{country}}^2}\right) \sim \text{loggamma}(\alpha = 1, \gamma = 2).$$

$$\log\left(\frac{1+\rho}{1-\rho}\right) \sim \text{Normal}(\mu = 4, \sigma^2 = 1.2^2)$$

Model 4: In this model, we used the default hyper-priors in INLA for less informative nugget and country random effects. The hyper-priors for the AR1 rho, ρ , were changed.

$$\log\left(\frac{1}{\sigma_{\text{nugget}}^2}\right) \sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}) \text{ and}$$

$$\log\left(\frac{1}{\sigma_{\text{country}}^2}\right) \sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}).$$

$$\log\left(\frac{1+\rho}{1-\rho}\right) \sim \text{Normal}(\mu = 0, \sigma^2 = 1.2^2)$$

Model 5: In this model, we used the default hyper-priors in INLA for both nugget and country random effects. The hyper-priors for the AR1 rho, ρ , were the default in INLA.

$$\log\left(\frac{1}{\sigma_{\text{nugget}}^2}\right) \sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}) \text{ and}$$

$$\log\left(\frac{1}{\sigma_{\text{country}}^2}\right) \sim \text{loggamma}(\alpha = 1, \gamma = 5 \times 10^{-5}).$$

$$\log\left(\frac{1+\rho}{1-\rho}\right) \sim \text{Normal}(\mu = 0, \sigma^2 = 2.58^2)$$

The predicted estimates for all models with different sets of hyper-priors were highly correlated at the grid-cell level and yielded low mean absolute differences (Supplementary Table 7). We ultimately selected the less informative priors for nugget and country random effects as they are default priors in the INLA package and have been applied widely^{76,77} and selected a more stringent parameterization of our space–time correlation, as indicated in model 1.

Mesh construction. We constructed the finite elements mesh for the stochastic partial differential equation approximation to the Gaussian process regression using a simplified polygon boundary (in which coastlines and complex boundaries were smoothed) for each of the regions within our model. We set the inner mesh triangle maximum edge length (the mesh size for areas over land) to be 0.75 degrees and the buffer maximum edge length (the mesh size for areas over the ocean) to be 5 degrees. An example finite elements mesh constructed for Eastern SSA mesh is described by Kinyoki et al.²¹.

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

Data availability

Our study follows the Guidelines for Accurate and Transparent Health Estimates Reporting⁴⁸ (Supplementary Table 1). The findings of this study are supported by data available in public online repositories, data publicly available upon request of the data provider and data not publicly available due to restrictions by the data provider. Nonpublicly available data were used under license for the current study but may be available from the authors upon reasonable request and with permission of the data provider. Details of data sources and availability can be found in Supplementary Tables 2–5. The full output of the analyses are publicly available in the Global Health Data Exchange (<http://ghdx.healthdata.org/record/ihme-data/lmic-double-burden-of-malnutrition-geospatial-estimates-2000-2017>) and can further be explored via customized data visualization tools (<https://vizhub.healthdata.org/lbd/dbm>). Administrative boundaries were retrieved from the Database of Global Administrative Areas³⁹. Land cover was retrieved from the online Data Pool, courtesy of the NASA EOSDIS Land Processes Distributed Active Archive Center, USGS/Earth Resources Observation and Science Center, Sioux Falls, South Dakota⁴⁰. Lakes were retrieved from the Global Lakes and Wetlands Database, courtesy of the World Wildlife Fund and the Center for Environmental Systems Research, University of Kassel^{41,42}. Populations were retrieved from WorldPop^{43,44}.

Code availability

All code used for these analyses is publicly available online at <http://ghdx.healthdata.org/record/ihme-data/lmic-double-burden-of-malnutrition-geospatial-estimates-2000-2017> and at <http://github.com/ihmeuw/lbd/tree/dbm-lmic-2020>.

References

47. Dicker, D. et al. Global, regional, and national age–sex–specific mortality and life expectancy, 1950–2017: a systematic analysis for the global burden of disease study 2017. *Lancet* **392**, 1684–1735 (2018).

48. Stevens, G. A. et al. Guidelines for accurate and transparent health estimates reporting: the GATHER statement. *PLoS Med.* **13**, e1002056 (2016).
49. USAID. Demographic and health surveys (DHS) <http://dhsprogram.com/>.
50. UNICEF. Multiple indicator cluster surveys (MICS) <http://mics.unicef.org>.
51. World Bank Group. Living standards measurement survey (LSMS) <http://go.worldbank.org/UK1ETMHBNO>.
52. World Bank Group. Core welfare indicators questionnaire survey (CWIQ) <http://ghdx.healthdata.org/series/core-welfare-indicators-questionnaire-survey-cwiq>.
53. Lumley, T. in *Complex Surveys: A Guide to Analysis Using R*. (Wiley, 2010).
54. Lumley, T. Analysis of complex survey samples. *J. Stat. Softw.* **9**, 1–19 (2004).
55. FAO. The global administrative unit layers (GAUL): technical aspects <http://www.fao.org/geonetwork/srv/en/main.home>.
56. Global Administrative Areas (GADM). GADM database of global administrative areas <http://www.gadm.org>.
57. WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. *Acta Paediatr. Suppl.* **450**, 76–85 (2006).
58. Indrayan, A. Demystifying LMS and BCPE methods of centile estimation for growth and other health parameters. *Indian Pediatr.* **51**, 37–43 (2014).
59. WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. *Acta Paediatr.* **95**, 76–85 (2006).
60. Bhatt, S. et al. Improved prediction accuracy for disease risk mapping using Gaussian process stacked generalization. *J. R. Soc. Interface* **14**, 20170520 (2017).
61. Fienberg, S. E. *The Analysis of Cross-Classified Categorical Data* (Springer, 2007); <https://doi.org/10.1007/978-0-387-72825-4>
62. Ananth, C. V. & Kleinbaum, D. G. Regression models for ordinal responses: a review of methods and applications. *Int. J. Epidemiol.* **26**, 1323–1333 (1997).
63. Mosser, J. F. et al. Mapping diphtheria–pertussis–tetanus vaccine coverage in Africa, 2000–2016: a spatial and temporal modelling study. *Lancet* **393**, 1843–1855 (2019).
64. Stein, M. L. *Interpolation of Spatial Data* (Springer, 1999).
65. Diggle, Peter J. & Ribeiro, Paulo J. *Model-based Geostatistics* (Springer, 2007); <https://doi.org/10.1007/978-0-387-48536-2>.
66. Rue, H., Martino, S. & Chopin, N. Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations. *J. R. Stat. Soc. Ser. B Stat. Methodol.* **71**, 319–392 (2009).
67. Martins, T. G., Simpson, D., Lindgren, F. & Rue, H. Bayesian computing with INLA: new features. *Comput. Stat. Data Anal.* **67**, 68–83 (2013).
68. Lindgren, F., Rue, H. & Lindström, J. An explicit link between Gaussian fields and Gaussian Markov random fields: the stochastic partial differential equation approach. *J. R. Stat. Soc. Ser. B Stat. Methodol.* **73**, 423–498 (2011).
69. Golding, N. et al. Mapping under-5 and neonatal mortality in Africa, 2000–15: a baseline analysis for the sustainable development goals. *Lancet* **390**, 2171–2182 (2017).
70. Osgood-Zimmerman, A. et al. Mapping child growth failure in Africa between 2000 and 2015. *Nature* **555**, 41–47 (2018).
71. Alegana, V. A. et al. Fine resolution mapping of population age–structures for health and development applications. *J. R. Soc. Interface* **12**, 20150073–20150073 (2015).
72. Patil, A. P., Gething, P. W., Piel, F. B. & Hay, S. I. Bayesian geostatistics in health cartography: the perspective of malaria. *Trends Parasitol.* **27**, 246–253 (2011).
73. Gething, P. W., Patil, A. P. & Hay, S. I. Quantifying aggregated uncertainty in *Plasmodium falciparum* malaria prevalence and populations at risk via efficient space–time geostatistical joint simulation. *PLoS Comput. Biol.* **6**, e1000724 (2010).
74. Scharlemann, J. P. W. et al. Global data for ecology and epidemiology: a novel algorithm for temporal Fourier processing MODIS data. *PLoS ONE* **3**, e1408 (2008).
75. Blangiardo, M. & Cameletti, M. in *Spatial and Spatio-temporal Bayesian Models with R-INLA* 235–258 (John Wiley & Sons, 2015).
76. Cameletti, M., Lindgren, F., Simpson, D. & Rue, H. Spatio-temporal modeling of particulate matter concentration through the SPDE approach. *ASTA Adv. Stat. Anal.* **97**, 109–131 (2013).
77. Blangiardo, M., Cameletti, M., Baio, G. & Rue, H. Spatial and spatio-temporal models with R-INLA. *Spat. Spatio-Temporal Epidemiol.* **7**, 39–55 (2013).

Acknowledgements

This work was primarily supported by grant OPP1132415 from the Bill & Melinda Gates Foundation awarded to S.I.H. The corresponding author had full access to data in the study and had final responsibility for the decision to submit the study for publication.

Author contributions

D.K.K., J.M.R., A.A. and S.I.H. conceived and planned the study. A.L.-A. and D.K.K. obtained, extracted, processed and geopositioned data. D.K.K. carried out statistical analyses. The first draft of the manuscript was written by D.K.K., J.M.R., S.B.M., L.E.S., A.A. and S.I.H.; D.K.K., S.B.M. and J.M.R. finalized the manuscript based on comments from other authors and reviewer feedback. D.K.K., A.L.-A. and S.B.M. managed the Supplementary Information. All authors provided intellectual input into aspects of this study. Additional details on author contributions are in the Supplementary Information.

Competing interests

This study was funded by the Bill & Melinda Gates Foundation. Co-authors employed by the Bill & Melinda Gates Foundation provided feedback on initial maps and drafts of this manuscript. Otherwise, the funders of the study had no role in study design, data collection, data analysis, data interpretation, writing of the final report or the decision to publish. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication. Dr Uddin reports personal fees from Deakin University Institute for Physical Activity and Nutrition, Australia, outside the submitted work. Dr Lorkowski reports personal fees from Akcea Therapeutics, Amedes MVZ für Laboratoriumsdiagnostik und Mikrobiologie, AMGEN, Berlin-Chemie, Boehringer Ingelheim Pharma, Daiichi Sankyo, MSD Sharp & Dohme, Novo Nordisk, Sanofi-Aventis, Synlab, Unilever and Upfield, as well as nonfinancial support from Preventicus outside the submitted work. Prof. Postma reports grants and personal fees from various pharmaceutical industries, all outside the submitted work. Prof. Postma holds stocks in Ingress Health and Pharmacoeconomics Advice Groningen and is advisor to Asc Academics, all pharmacoeconomic consultancy companies. Dr Remuzzi reports personal fees and nonfinancial support from Alnylam, personal fees and nonfinancial support from Boehringer Ingelheim, personal fees and nonfinancial support from Handock Inc., personal fees and nonfinancial support from Inception Sciences Canada and personal fees and nonfinancial support from Achillion, outside the submitted work. Dr Jakovljevic reports grants from Ministry of Education Science and Technological Development of the Republic of Serbia outside the submitted work. Dr Flohr reports grants from European Union IMI grant scheme (Horizon 2020) outside the submitted work. Dr Jozwiak reports personal fees from ALAB LABORATORIA,

nonfinancial support from SERVIER, nonfinancial support from MICROLIFE, personal fees from TEVA POLSKA, nonfinancial support from SUPERPHARM and nonfinancial support from MEDICOVER, outside the submitted work. W. Mendoza is currently Program Analyst Population and Development at the United Nations Population Fund-UNFPA Country Office in Peru, which does not necessarily endorse this study. Prof. Saxena reports grants from NIHR School for Public Health Research, grants from NIHR Applied Research Collaboration and grants from The Daily Mile Foundation supported by INEOS, outside the submitted work. Dr Dunachie reports grants from The Fleming Fund at UK Department of Health and Social Care, during the conduct of the study. Dr Mozaffarian reports research funding from the National Institutes of Health and the Gates Foundation; personal fees from GOED, Nutrition Impact, Bunge, Indigo Agriculture, Motif FoodWorks, Amarin, Acasti Pharma, Cleveland Clinic Foundation, America's Test Kitchen and Danone; scientific advisory board, Brightseed, DayTwo, Elysium Health and Filtricine; and chapter royalties from UpToDate; all outside the submitted work. Dr J. Singh reports personal fees from Crealta/Horizon, Medisys, Fidia, UBM LLC, Medscape, WebMD, Clinical Care Options, Clearview Healthcare Partners, Putnam Associates, Spherix, the National Institutes of Health and the American College of Rheumatology, stock options in Amarin Pharmaceuticals and Viking Pharmaceuticals and participates in the steering committee of OMERACT, an international organization that develops measures for clinical trials receives arm's length funding from 12 pharmaceutical companies and is also on the speaker's bureau of Simply Speaking.

Additional information

Extended data is available for this paper at <https://doi.org/10.1038/s41591-020-0807-6>.

Supplementary information is available for this paper at <https://doi.org/10.1038/s41591-020-0807-6>.

Correspondence and requests for materials should be addressed to S.I.H.

Peer review information Jennifer Sargent was the primary editor on this article and managed its editorial process and peer review in collaboration with the rest of the editorial team.

Reprints and permissions information is available at www.nature.com/reprints.

LBD Double Burden of Malnutrition Collaborators

Damaris K. Kinyoki^{1,2}, Jennifer M. Ross^{1,3,4}, Alice Lazzar-Atwood¹, Sandra B. Munro¹, Lauren E. Schaeffer¹, Mahdiah Abbasalizad-Farhangi⁵, Masoumeh Abbasi⁶, Hedayat Abbastabar⁷, Ahmed Abdelalim⁸, Amir Abdoli⁹, Mohammad Abdollahi¹⁰, Ibrahim Abdollahpour¹¹, Rizwan Suliankatchi Abdulkader¹², Nebiyu Dereje Abebe^{13,14}, Teshome Abuka Abebo¹⁵, Kedir Hussein Abegaz^{16,17}, Hassan Abolhassani^{18,19}, Lucas Guimarães Abreu²⁰, Michael R. M. Abrigo²¹, Abdelrahman I. Abushouk²², Manfred Mario Kokou Accrombessi²³, Dilaram Acharya^{24,25}, Maryam Adabi²⁶, Akindele Olupelumi Adebisi^{27,28}, Isaac Akinkunmi Adedeji²⁹, Victor Adekanmbi³⁰, Abiodun Moshood Adeoye^{31,32}, Olatunji O. Adetokunboh^{33,34}, Davoud Adham³⁵, Posi Emmanuel Aduroja³⁶, Shailesh M. Advani^{37,38}, Mohsen Afarideh³⁹, Mohammad Aghaali⁴⁰, Anurag Agrawal^{41,42}, Tauseef Ahmad^{43,44}, Keivan Ahmadi⁴⁵, Sepideh Ahmadi⁴⁶, Muktar Beshir Ahmed⁴⁷, Rushdia Ahmed^{48,49}, Olufemi Ajumobi^{50,51}, Chalachew Genet Akal⁵², Temesgen Yihunie Akalu⁵³, Tomi Akinyemiju^{54,55}, Blessing Akombi⁵⁶, Ziyad Al-Aly^{57,58}, Samiah Alam⁵⁹, Genet Melak Alamene⁶⁰, Turki M. Alanzi⁶¹, Jacqueline Elizabeth Alcalde Rabanal⁶², Niguse Meles Alema⁶³, Beriwan Abdulqadir Ali^{64,65}, Muhammad Ali⁶⁶, Mehran Alijanzadeh⁶⁷, Cyrus Alinia⁶⁸, Vahid Alipour^{69,70}, Hesam Alizade^{71,72}, Syed Mohamed Aljunid^{73,74}, Afshin Almasi⁷⁵, Amir Almasi-Hashiani⁷⁶, Hesham M. Al-Mekhlafi^{77,78}, Rajaa M. Al-Raddadi⁷⁹, Khalid Altirkawi⁸⁰, Nelson Alvis-Guzman^{81,82}, Nelson J. Alvis-Zakzuk^{83,84}, Azmeraw T. Amare^{85,86}, Adeladza Kofi Amegah⁸⁷, Saeed Amini⁸⁸, Mostafa Amini Rarani⁸⁹, Fatemeh Amiri⁹⁰, Arianna Maeve Loreche Amit^{91,92}, Nahla Hamed Anber⁹³, Catalina Liliana Andrei⁹⁴, Fereshteh Ansari^{95,96}, Alireza Ansari-Moghaddam⁹⁷, Zelalem Alamrew Anteneh⁹⁸, Carl Abelardo T. Antonio^{99,100}, Ernoiz Antriyandarti¹⁰¹, Davood Anvari^{102,103}, Raziq Anwer¹⁰⁴,

Seth Christopher Yaw Appiah^{105,106}, Jalal Arabloo⁶⁹, Morteza Arab-Zozani¹⁰⁷, Ephrem Mebrahtu Araya⁶³, Zohreh Arefi¹⁰⁸, Olatunde Aremu¹⁰⁹, Johan Ärnlov^{110,111}, Afsaneh Arzani^{112,113}, Mehran Asadi-Aliabadi¹¹⁴, Ali A. Asadi-Pooya¹¹⁵, Samaneh Asgari¹¹⁶, Babak Asghari¹¹⁷, Alebachew Fasil Ashagre¹¹⁸, Anemaw A. Asrat⁹⁸, Bahar Ataeinia¹¹⁹, Hagos Tasew Atalay¹²⁰, Desta Debalkie Atnafu¹²¹, Maha Moh'd Wahbi Atout¹²², Marcel Ausloos^{123,124}, Euripide F. G. A. Avokpaho^{125,126}, Ashish Awasthi¹²⁷, Beatriz Paulina Ayala Quintanilla^{128,129}, Martin Amogre Ayanore¹³⁰, Yared A. Asmare Aynalem¹³¹, Abbas Azadmehr¹³², Samad Azari⁶⁹, Ghasem Azarian¹³³, Zelalem Nigussie Azene¹³⁴, Ebrahim Babaee¹¹⁴, Alaa Badawi^{135,136}, Ashish D. Badiye¹³⁷, Mohamad Amin Bahrami¹³⁸, Atif Amin A. Baig^{139,140}, Ahad Bakhtiari¹⁴¹, Shankar M. Bakkannavar¹⁴², Senthilkumar Balakrishnan¹⁴³, Ayele Geleto Bali¹⁴⁴, Maciej Banach^{145,146}, Palash Chandra Banik¹⁴⁷, Zahra Baradaran-Seyed¹⁴⁸, Adhanom Gebreegziabher Baraki⁵³, Miguel A. Barboza^{149,150}, Till Winfried Bärnighausen^{151,152}, Lingkan Barua¹⁴⁷, Huda Basaleem¹⁵³, Sanjay Basu¹⁵⁴, Mohsen Bayati¹⁵⁵, Mulat Tirfie Bayih¹⁵⁶, Habtamu Wondifraw Baynes¹⁵⁷, Neeraj Bedi^{158,159}, Masoud Behzadifar¹⁶⁰, Meysam Behzadifar¹⁶¹, Yibeltal Alemu Bekele¹⁶², Derrick A. Bennett¹⁶³, Dessalegn Ajema Berbada¹⁶⁴, Kidanemariam Berhe¹⁶⁵, Abadi Kidanemariam Berhe^{166,167}, Adam E. Berman¹⁶⁸, Robert S. Bernstein^{169,170}, Reshmi Bhageerathy¹⁷¹, Dinesh Bhandari^{172,173}, Pankaj Bharadwaj^{174,175}, Natalia V. Bhattacharjee¹, Kritika Bhattacharyya^{176,177}, Ali Bijani¹⁷⁸, Boris Bikbov¹⁷⁹, Ver Bilano¹⁸⁰, Nigus Bililign¹⁸¹, Muhammad Shahdaat Bin Sayeed^{182,183}, Setognal Birara¹⁸⁴, Minuye Biniam Biniam Birhane¹⁸⁵, Minyichil Birhanu¹⁸⁶, Raaj Kishore Biswas^{187,188}, Zebenay Workneh Bitew¹⁸⁹, Kassawmar Angaw Bogale⁹⁸, Somayeh Bohlouli¹⁹⁰, Srinivasa Rao Bolla¹⁹¹, Archith Bloor¹⁹², Antonio M. Borzi¹⁹³, Shiva Borzouei¹⁹⁴, Oliver J. Brady¹⁹⁵, Nicola Luigi Bragazzi¹⁹⁶, Dejana Braithwaite¹⁹⁷, Nikolay Ivanovich Briko¹⁹⁸, Gabrielle Britton¹⁹⁹, Shyam S. Budhathoki²⁰⁰, Sharath Burugina Nagaraja²⁰¹, Reinhard Busse²⁰², Zahid A. Butt^{203,204}, Lucero Cahuana-Hurtado⁶², Luis Alberto Cámara^{205,206}, Ismael R. Campos-Nonato²⁰⁷, Jorge Cano²⁰⁸, Josip Car^{209,210}, Rosario Cárdenas²¹¹, Juan J. Carrero²¹², Félix Carvalho²¹³, João Mauricio Castaldelli-Maia²¹⁴, Carlos A. Castañeda-Orjuela^{215,216}, Franz Castro¹⁹⁹, Ester Cerin^{217,218}, Collins Chansa^{219,220}, Jaykaran Charan²²¹, Pranab Chatterjee²²², Vijay Kumar Chattu²²³, Bal Govind Chauhan^{224,225}, Ali Reza Chavshin²²⁶, Mohammad Chehrazai^{227,228}, Tesfaye Yitna Chichiabellu²²⁹, Ken Lee Chin²³⁰, Devasahayam J. Christopher²³¹, Dinh-Toi Chu²³², Flavia M. Cicuttini²³³, Michael L. Collison¹, Michael A. Cork¹, Natalie Cormier¹, Paolo Angelo Cortesi²³⁴, Vera M. Costa²¹³, Abel Fekadu Fekadu Dadi^{235,236}, Baye Dagne²³⁷, Saad M. A. Dahlawi²³⁸, Giovanni Damiani^{239,240}, Amira Hamed Darwish²⁴¹, Ahmad Daryani²⁴², Jai K. Das²⁴³, Rajat Das Gupta^{48,244}, Claudio Dávila-Cervantes²⁴⁵, Nicole Davis Weaver¹, Diego De Leo²⁴⁶, Jan-Walter De Neve¹⁵¹, Feleke Mekonnen Demeke⁵², Asmamaw Bizuneh Demis^{247,248}, Dereje Bayissa Demissie^{249,250}, Gebre Teklemariam Demoz^{251,252}, Edgar Denova-Gutiérrez²⁵³, Kebede Deribe^{13,254}, Rupak Desai²⁵⁵, Beruk Berhanu Desalegn²⁵⁶, Assefa Desalew²⁵⁷, Aniruddha Deshpande¹, Sagnik Dey²⁵⁸, Samath Dhamminda Dharmaratne^{1,259}, Preeti Dhillon²⁶⁰, Meghnath Dhimal²⁶¹, Govinda Prasad Dhungana²⁶², Mostafa Dianati Nasab²⁶³, Daniel Diaz^{264,265}, Zahra Sadat Dibaji Forooshani²⁶⁶, Girmaye Deye Dinsa^{152,267}, Isaac Oluwafemi Dipeolu³⁶, Shirin Djalalinia²⁶⁸, Hoa Thi Do²⁶⁹, Huyen Phuc Do²⁷⁰, Paul Narh Doku²⁷¹, Fariba Dorostkar²⁷², Leila Doshmangir²⁷³, Manisha Dubey²⁷⁴, Bereket Duko Adema^{275,276}, Susanna J. Dunachie^{277,278}, Bruce B. Duncan²⁷⁹, Andre R. Durães^{280,281}, Lucas Earl¹, Hamed Ebrahimzadeh Leylabadlo²⁸², Aziz Eftekhari^{283,284}, Iman El Sayed²⁸⁵, Maysaa El Sayed Zaki²⁸⁶, Maha El Tantawi²⁸⁷, Iffat Elbarazi²⁸⁸,

Demelash Abewa Elemineh²⁸⁹, Shaimaa I. El-Jaafary⁸, Ziad El-Khatib^{290,291}, Aisha Elsharkawy²⁹², Yasser Mohamed El-Sherbiny^{286,293}, Iqbal R. F. Elyazar²⁹⁴, Mohammad Hassan Emamian²⁹⁵, Shymaa Enany²⁹⁶, Daniel Adane Endalew²⁹⁷, Melese Linger Endalifer²⁹⁸, Khalil Eskandari^{299,300}, Sharareh Eskandarieh³⁰¹, Saman Esmaeilnejad³⁰², Alireza Esteghamati³⁹, Arash Etemadi^{303,304}, Atkilt Esaiyas Etilso³⁰⁵, Jessica Fanzo^{306,307}, Mohammad Farahmand³⁰⁸, Anwar Faraj³⁰⁹, Sajjad Farashi³¹⁰, Mohammad Fareed³¹¹, Andrea Farioli³¹², Andre Faro³¹³, Farshad Farzadfar¹¹⁹, Hossein Farzam⁶, Syeda Sadia Fatima³¹⁴, Nazir Fattahi⁷⁵, Nelsensius Klau Fauk^{315,316}, Ali Akbar Fazaeli³¹⁷, Netsanet Fentahun³¹⁸, Tomas Y. Ferede³¹⁹, Seyed-Mohammad Fereshtehnejad^{110,320}, Eduarda Fernandes³²¹, João C. Fernandes³²², Garumma Tolu Feyissa^{323,324}, Irina Filip^{325,326}, Florian Fischer³²⁷, Carsten Flohr³²⁸, Nataliya A. Foigt³²⁹, Morenike Oluwatoyin Folayan³³⁰, Artem Alekseevich Fomenkov³³¹, Masoud Foroutan³³², Jana Förster³³³, Joel Msafiri Francis³³⁴, Takeshi Fukumoto^{335,336}, Reta Tsegaye Gayesa³³⁷, Biniyam Sahiledengle Geberemariam³³⁸, Tsegaye Tewelde Gebrehiwot⁴⁷, Hadush Gebremariam¹⁶⁵, Kidane Tadesse Gebremariam³³⁹, Ketema Bizuwork Bizuwork Gebremedhin³⁴⁰, Gebreamlak Gebremedhn Gebremeskel^{120,341}, Assefa Ayalew Ayalew Gebreslassie³³⁹, Gebretsadkan G. G. Gebretsadik¹⁶⁵, Getnet Azeze Gedefaw^{86,342}, Yilma Chisha Dea Geramo¹⁶⁴, Hailay Abrha Gesesew^{47,315}, Birhanu Geta³⁴³, Agegnehu Bante Getenet³⁴⁴, Kebede Embaye Gezae³⁴⁵, Fatemeh Ghaffarifar³⁴⁶, Mansour Ghafourifard³⁴⁷, Alireza Ghajar^{39,348}, Mahsa Ghajarzadeh³⁴⁹, Ahmad Ghashghae³⁵⁰, Hesam Ghiasvand³⁵¹, Asadollah Gholamian^{352,353}, Syed Amir Gilani^{354,355}, Tiffany K. Gill³⁵⁶, Ibrahim Abdelmageed Ginawi³⁵⁷, Srinivas Goli^{225,358}, Nelson G. M. Gomes^{321,359}, Sameer Vali Gopalani^{360,361}, Houman Goudarzi^{362,363}, Alessandra C. Goulart^{364,365}, Arunkumar Govindakarnavar³⁶⁶, Ayman Grada³⁶⁷, Michal Grivna²⁸⁸, Rafael Alves Guimarães³⁶⁸, Rashid Abdi Guled³⁶⁹, Yuming Guo^{233,370}, Rahul Gupta^{371,372}, Rajeev Gupta^{373,374}, Nima Hafezi-Nejad^{375,376}, Michael Tamene Haile³⁷⁷, Arvin Haj-Mirzaian^{378,379}, Arya Haj-Mirzaian^{375,378}, Brian J. Hall³⁸⁰, Iman Halvaei³⁸¹, Randah R. Hamadeh³⁸², Yadollah Hamidi³⁸³, Demelash Woldeyohannes Handiso³³⁸, Graeme J. Hankey^{384,385}, Hamidreza Haririan³⁸⁶, Ninuk Hariyani^{387,388}, Ahmed I. Hasaballah³⁸⁹, Md. Mehedi Hasan³⁹⁰, Milad Hasankhani⁵, Edris Hasanpoor³⁹¹, Amir Hasanzadeh^{392,393}, Maryam Hashemian³⁹⁴, Soheil Hassanipour^{395,396}, Hamid Yimam Hassen^{397,398}, Rasmus Havmoeller³⁹⁹, Corinna Hawkes⁴⁰⁰, Khezar Hayat^{401,402}, Desta Haftu Hayelom¹⁶⁴, Behnam Heidari³⁹, Reza Heidari-Soureshjani⁴⁰³, Delia Hendrie⁴⁰⁴, Andualem Henok³⁹⁷, Nathaniel J. Henry¹, Mario Herrero⁴⁰⁵, Claudiu Herteliu¹²⁴, Fatemeh Heydarpour⁴⁰⁶, Hagos D. de Hidru⁴⁰⁷, Chi Linh Hoang²⁷⁰, Hans W. Hoek^{408,409}, Michael K. Hole⁴¹⁰, Ramesh Holla⁴¹¹, Gillian Hollerich¹, Enayatollah Homaie Rad^{412,413}, Sung Hwi Hong^{414,415}, Praveen Hoogar⁴¹⁶, Masako Horino⁴¹⁷, Naznin Hossain^{418,419}, Mostafa Hosseini⁴²⁰, Mehdi Hosseinzadeh^{421,422}, Mihaela Hostiuc^{423,424}, Sorin Hostiuc^{425,426}, Mowafa Housseh⁴²⁷, Mohamed Hsairi⁴²⁸, Guoqing Hu⁴²⁹, Tanvir M. Huda^{430,431}, Ayesha Humayun⁴³², Bing-Fang Hwang⁴³³, Segun Emmanuel Ibitoye³⁶, Olayinka Stephen Ilesanmi²⁷, Milena D. Ilic⁴³⁴, Mohammad Hasan Imani-Nasab⁴³⁵, LEEBERK Raja Inbaraj⁴³⁶, Usman Iqbal⁴³⁷, Seyed Sina Naghibi Irvani⁴³⁸, Sheikh Mohammed Shariful Islam^{439,440}, Chidozie C. D. Iwu⁴⁴¹, Chinwe Juliana Iwu^{442,443}, Neda Izadi⁴⁴⁴, Jalil Jaafari⁴⁴⁵, Anelisa Jaca^{446,447}, Farhad Jadidi-Niaragh⁴⁴⁸, Nader Jafari Balalami⁴⁴⁹, Morteza Jafarinia⁴⁵⁰, Mohammad Ali Jahani¹¹³, Mihajlo Jakovljevic⁴⁵¹, Amir Jalali⁴⁵², Farzad Jalilian^{453,454}, Achala Upendra Jayatilleke^{455,456}, Panniyammakal Jeemon⁴⁵⁷, Fyezah Jehan⁴⁵⁸, Ensiyeh Jenabi⁴⁵⁹, Ravi Prakash Jha⁴⁶⁰, Vivekanand Jha^{461,462}, John S. Ji^{463,464},

Peng Jia⁴⁶⁵, Oommen John⁴⁶², Yetunde O. John-Akinola³⁶, Kimberly B. Johnson¹, Jost B. Jonas^{466,467}, Nitin Joseph⁴⁶⁸, Farahnaz Joukar³⁹⁵, Jacek Jerzy Jozwiak⁴⁶⁹, Suresh Banayya Jungari⁴⁷⁰, Mikk Jürisson⁴⁷¹, Ali Kabir⁴⁷², Zubair Kabir⁴⁷³, Amaha Kahsay¹⁶⁵, Molla Kahsay¹⁸⁴, Hamed Kalani⁴⁷⁴, Leila L. Kalankesh⁴⁷⁵, Rohollah Kalhor^{67,476}, Zahra Kamiab⁴⁷⁷, Tanuj Kanchan⁴⁷⁸, Umesh Kapil⁴⁷⁹, Neeti Kapoor¹³⁷, Manoochehr Karami⁴⁸⁰, Behzad Karami Matin⁷⁵, André Karch⁴⁸¹, Mohd A. Karim^{163,431}, Surendra Karki^{56,482}, Amir Kasaeian^{483,484}, Gebremicheal Gebreslassie Kasahun²⁵¹, Habtamu Kebebe Kasaye³³⁷, Tesfaye Dessale Kassa⁴⁸⁵, Hagazi Gebremedhin Kassaye⁶³, Nicholas J. Kassebaum^{1,486}, Ali Kazemi Karyani^{75,487}, Andre Pascal Kengne^{488,489}, Daniel Bekele Ketema⁴⁹⁰, Yousef Saleh Khader⁴⁹¹, Morteza Abdullatif Khafaie⁴⁹², Mojtaba Khaksarian⁴⁹³, Nauman Khalid⁴⁹⁴, Ibrahim A. Khalil³, Rovshan Khalilov⁴⁹⁵, Asad Khan⁴⁹⁶, Ejaz Ahmad Khan⁴⁹⁷, Md Nuruzzaman Khan^{498,499}, Mohammad Saud Khan⁵⁰⁰, Muhammad Shahzeb Khan^{501,502}, Khaled Khatab^{503,504}, Amir Khater⁵⁰⁵, Mona M. Khater⁵⁰⁶, Mahalqua Nazli Khatib⁵⁰⁷, Maryam Khayamzadeh^{508,509}, Maryam Khazaei-Pool⁵¹⁰, Mohammad Khazaei¹³³, Salman Khazaei⁴⁸⁰, Mohammad Taghi Khodayari⁵¹¹, Mohammad Hossein Khosravi⁵¹², Roba Khundkar⁵¹³, Ali Kiadaliri⁵¹⁴, Neda Kianipour⁴⁸⁷, Daniel N. Kiirithio⁵¹⁵, Yun Jin Kim⁵¹⁶, Ruth W. Kimokoti⁵¹⁷, Adnan Kisa⁵¹⁸, Sezer Kisa⁵¹⁹, Tufa Kolola⁵²⁰, Hamidreza Komaki^{521,522}, Shivakumar K. M. Kondlahalli⁵²³, Ali Koolivand⁵²⁴, Parvaiz A. Koul⁵²⁵, Ai Koyanagi⁵²⁶, Moritz U. G. Kraemer^{527,528}, Kewal Krishan⁵²⁹, Kris J. Krohn¹, Nuworza Kugbey^{530,531}, Manasi Kumar^{532,533}, Pushpendra Kumar²²⁵, Vivek Kumar⁵³⁴, Om P. Kurmi^{535,536}, Oluwatosin Kuti⁵³⁷, Carlo La Vecchia⁵³⁸, Ben Lacey^{163,539}, Deepesh P. Lad⁵⁴⁰, Aparna Lal¹⁸², Dharmesh Kumar Lal⁵⁴¹, Faris Hasan Lami⁵⁴², Prabhat Lamichhane⁵⁴³, Justin J. Lang⁵⁴⁴, Van C. Lansingh^{545,546}, Savita Lasrado⁵⁴⁷, Georgy Lebedev^{548,549}, Paul H. Lee⁵⁵⁰, Shaun Wen Huey Lee^{551,552}, Mostafa Leili¹³³, Ian D. Letourneau¹, Sonia Lewycka^{277,553}, Shanshan Li²³³, Lee-Ling Lim^{554,555}, Shai Linn⁵⁵⁶, Shiwei Liu⁵⁵⁷, Simin Liu⁵⁵⁸, Rakesh Lodha⁵⁵⁹, Joshua Longbottom⁵⁶⁰, Jaifred Christian F. Lopez^{561,562}, Stefan Lorkowski^{563,564}, Erlyn Rachelle King Macarayan^{565,566}, Mohammed Madadin⁵⁶⁷, Hassan Magdy Abd El Razek⁵⁶⁸, Muhammed Magdy Abd El Razek⁵⁶⁹, Dhaval P. Maghavani⁵⁷⁰, Phetole Walter Mahasha³⁴, Narayan Bahadur Mahotra⁵⁷¹, Venkatesh Maled^{572,573}, Afshin Maleki⁵⁷⁴, Shokofeh Maleki⁵⁷⁵, Deborah Carvalho Malta⁵⁷⁶, Ali Manafi⁵⁷⁷, Farzad Manafi⁵⁷⁸, Navid Manafi^{579,580}, Narendar Dawanu Manohar⁵⁸¹, Fariborz Mansour-Ghanaei³⁹⁵, Borhan Mansouri⁵⁸², Mohammad Ali Mansournia⁴²⁰, Chabila Christopher Mapoma⁵⁸³, Dadi Marami¹⁴³, Laurie B. Marczak¹, Carlos Alberto Marrugo Arnedo^{584,585}, Francisco Rogerlândio Martins-Melo⁵⁸⁶, Anthony Masaka⁵⁸⁷, Benjamin Ballard Massenbourg⁵⁸⁸, Pallab K. Maulik^{589,590}, Benjamin K. Mayala^{1,591}, Mohsen Mazidi⁵⁹², Man Mohan Mehndiratta^{593,594}, Freshteh Mehri⁵⁹⁵, Kala M. Mehta⁵⁹⁶, Wahengbam Bigyananda Meitei⁵⁹⁷, Fantahun Ayenew Mekonnen⁵³, Teferi Mekonnen⁵⁹⁸, Gebrekiros Gebremichael Meles¹⁶⁴, Hagazi Gebre Meles⁵⁹⁹, Addisu Melese⁵², Walter Mendoza⁶⁰⁰, Ritesh G. Menezes⁶⁰¹, Meresa Berwo Mengesha⁶⁰², George A. Mensah^{489,603}, Tuomo J. Meretoja^{604,605}, Tomasz Miazgowski⁶⁰⁶, Neda Milevska Kostova⁶⁰⁷, Ted R. Miller^{404,608}, Edward J. Mills⁶⁰⁹, G. K. Mini^{457,610}, Seyed Mostafa Mir^{611,612}, Mohammad Miri⁶¹³, Hamed Mirjalali⁶¹⁴, Erkin M. Mirrakhimov^{615,616}, Hamed Mirzaei⁶¹⁷, Maryam Mirzaei⁶¹⁸, Roya Mirzaei⁶¹⁹, Mehdi Mirzaei-Alavijeh^{453,454}, Prasanna Mithra⁴⁶⁸, Babak Moazen¹⁵¹, Efat Mohamadi⁶²⁰, Amjad Mohamadi-Bolbanabad⁶²¹, Karzan Abdulmuhsin Mohammad^{65,622}, Yousef Mohammad⁶²³, Dara K. Mohammad^{624,625}, Aso Mohammad Darwesh⁶²⁶, Naser Mohammad Gholi Mezerji⁶²⁷, Abdollah Mohammadian-Hafshejani⁶²⁸, Mousa Mohammadnia-Afrouzi⁶²⁹,

Milad Mohammadoo-Khorasani⁶³⁰, Reza Mohammadpourhodki⁶³¹, Salahuddin Mohammed^{632,633}, Shafiu Mohammed^{151,634}, Jemal Abdu Mohammed¹⁸⁴, Ammas Siraj Mohammed⁶³⁵, Farnam Mohebi^{119,636}, Amin Mokari⁶³⁷, Ali H. Mokdad^{1,2}, Julio Cesar Montañez⁶³⁸, Pablo A. Montero-Zamora^{62,639}, Yoshan Moodley⁶⁴⁰, Maryam Moossavi⁶⁴¹, Ghobad Moradi^{621,642}, Masoud Moradi^{6,75}, Yousef Moradi⁶⁴³, Mohammad Moradi-Joo⁶⁴⁴, Maziar Moradi-Lakeh¹¹⁴, Farhad Moradpour⁶²¹, Rahmatollah Moradzadeh⁷⁶, Paula Moraga⁶⁴⁵, Shane Douglas Morrison⁶⁴⁶, Abbas Mosapour^{611,647}, Jonathan F. Mosser¹, Simin Mouodi¹¹³, Amin Mousavi Khaneghah⁶⁴⁸, Dariush Mozaffarian⁶⁴⁹, Ulrich Otto Mueller^{650,651}, Christopher J. L. Murray^{1,2}, G. V. S. Murthy⁶⁵², Kamarul Imran Musa⁶⁵³, Ghulam Mustafa^{654,655}, Saravanan Muthupandian⁶⁵⁶, Behnam Nabavizadeh⁶⁵⁷, Mehdi Naderi⁵⁷⁵, Girish N. Nadkarni⁶⁵⁸, Ahamarshan Jayaraman Nagarajan^{659,660}, Mohsen Naghavi^{1,2}, Aliya Naheed⁶⁶¹, Gurudatta Naik⁶⁶², Farid Najafi⁶⁶³, Jobert Richie Nansseu^{664,665}, K. M. Venkat Narayan¹⁶⁹, Bruno Ramos Nascimento⁶⁶⁶, Vinod Nayak¹⁴², Javad Nazari^{667,668}, Duduzile Edith Ndwandwe³⁴, Ionut Negoii^{423,669}, Ruxandra Irina Negoii^{670,671}, Josephine W. Ngunjiri⁶⁷², Cuong Tat Nguyen⁶⁷³, Huong Lan Thi Nguyen⁶⁷³, Dabere Nigatu¹⁶², Yesdhambel T. Nigatu^{674,675}, Rajan Nikbakhsh^{676,677}, Dina Nur Anggraini Ningrum^{678,679}, Chukwudi A. Nnaji^{34,680}, Vuong Minh Nong⁶⁷³, Jean Jacques Noubiap⁴⁸⁹, Christoph Nowak⁶⁸¹, Bogdan Oancea⁶⁸², Richard Ofori-Asenso^{683,684}, Onome Bright Oghenetega⁶⁸⁵, In-Hwan Oh⁶⁸⁶, Olanrewaju Oladimeji^{687,688}, Morteza Oladnabi⁶⁸⁹, Andrew T. Olagunju^{690,691}, Tinuke O. Olagunju⁵³⁵, Bolajoko Olubukunola Olusanya⁶⁹², Jacob Olusegun Olusanya⁶⁹³, Mojisola Morenike Oluwasanu³⁶, Muktar Omer Omer⁶⁹⁴, Obinna E. Onwujekwe⁶⁹⁵, Kwaku Oppong Asante^{531,696}, Eyal Oren^{697,698}, Orish Ebere Orisakwe⁶⁹⁹, Alberto Ortiz^{700,701}, Osayomwanbo Osarenotor⁷⁰², Aaron E. Osgood-Zimmerman¹, Mayowa Ojo Owolabi⁷⁰³, Mahesh P. A.⁷⁰⁴, Jagadish Rao Padubidri⁷⁰⁵, Keyvan Pakshir⁷⁰⁶, Adrian Pana^{124,707}, Songhomitra Panda-Jonas⁷⁰⁸, Hadi Parsian⁶¹¹, Tahereh Pashaei⁵⁷⁴, Deepak Kumar Pasupula⁷⁰⁹, Sangram Kishor Patel^{710,711}, Ashish Pathak^{712,713}, Mona Pathak⁷¹⁴, Sanghamitra Pati⁷¹⁵, Ajay Patle^{716,717}, George C. Patton^{718,719}, Kebreab Paulos⁷²⁰, Hamidreza Pazoki Toroudi⁷²¹, Veincent Christian Filipino Pepito⁷²², Norberto Perico⁷²³, William A. Petri⁷²⁴, Brandon V. Pickering¹, David M. Pigott^{1,2}, Majid Pirestani³⁴⁶, Bakhtiar Piroozi⁶²¹, Meghdad Pirsaeheb⁷⁵, Khem Narayan Pokhrel⁷²⁵, Maarten J. Postma^{726,727}, Hadi Pourjafar^{728,729}, Farshad Pourmalek⁷³⁰, Reza Pourmirza Kalhori⁷³¹, Akram Pourshams⁷³², Hossein Poustchi⁷³², Sergio I. Prada⁷³³, Liliana Preotescu^{734,735}, Dimas Ria Angga Pribadi⁷³⁶, Zahiruddin Quazi Syed¹⁷⁵, Mohammad Rabiee⁷³⁷, Navid Rabiee⁷³⁸, Amir Radfar^{739,740}, Alireza Rafiei^{741,742}, Fakher Rahim^{743,744}, Vafa Rahimi-Movaghar⁷⁴⁵, Muhammad Aziz Rahman^{746,747}, Sajjad ur Rahman^{748,749}, Rajesh Kumar Rai^{750,751}, Ali Rajabpour-Sanati⁷⁵², Fatemeh Rajati⁷⁵, Kiana Ramezanzadeh⁷⁵³, Saleem Muhammad Rana^{754,755}, Chhabi Lal Ranabhat^{756,757}, Sowmya J. Rao⁷⁵⁸, Davide Rasella^{759,760}, Vahid Rashedi⁷⁶¹, Prateek Rastogi⁷⁰⁵, Priya Rathi⁷⁶², Salman Rawaf^{763,764}, David Laith Rawaf^{765,766}, Lal Rawal⁷⁶⁷, Sarah E. Ray¹, Giuseppe Remuzzi⁷²³, Vishnu Renjith⁷⁶⁸, Andre M. N. Renzaho^{769,770}, Serge Resnikoff^{771,772}, Nima Rezaei^{19,773}, Shahab Rezaeian⁶, Mohammad Sadegh Rezaei⁷⁷⁴, Aziz Rezapour⁶⁹, Seyed Mohammad Riahi^{444,775}, Ana Isabel Ribeiro⁷⁷⁶, Jennifer Rickard^{777,778}, Alina Rodriguez^{779,780}, Leonardo Roever⁷⁸¹, Elias Merdassa Roro^{782,783}, Gholamreza Roshandel^{732,784}, Ali Rostami⁷⁸⁵, Enrico Rubagotti^{786,787}, Anas M. Saad⁷⁸⁸, Seyedmohammad Saadatagah⁷⁸⁹, Yogesh Damodar Sabde⁷⁹⁰, Siamak Sabour⁴⁴⁴, Ehsan Sadeghi⁷⁵, Masoumeh Sadeghi⁷⁹¹, Saeed Safari⁷⁹², Yahya Safari⁷⁵, Hamid Safarpour⁷⁹³, Rajesh Sagar⁷⁹⁴, Amirhossein Sahebkar^{795,796}, Mohammad Ali Sahraian³⁰¹, S. Mohammad Sajadi⁷⁹⁷, Mohammad Reza Salahshoor⁷⁹⁸, Nasir Salam⁷⁹⁹,

Farkhonde Salehi⁸⁰⁰, Saleh Salehi Zahabi^{801,802}, Hosni Salem⁸⁰³, Marwa R. Rashad Salem⁸⁰⁴, Yahya Salimi^{453,454,663}, Hamideh Salimzadeh⁷³², Hossein Samadi Kafil⁸⁰⁵, Evanson Zondani Sambala³⁴, Abdallah M. Samy⁸⁰⁶, Itamar S. Santos⁸⁰⁷, Bruno Piassi Sao Jose⁸⁰⁸, Sivan Yegnanarayana Iyer Saraswathy^{809,810}, Abdur Razzaque Sarker⁸¹¹, Benn Sartorius^{2,812}, Arash Sarveazad⁸¹³, Brijesh Sathian^{814,815}, Maheswar Satpathy^{816,817}, Sonia Saxena¹⁵⁴, Mehdi Sayyah³⁹, Alyssa N. Sbarra¹, Megan F. Schipp¹, Maria Inês Schmidt²⁷⁹, Aletta Elisabeth Schutte^{818,819}, David C. Schwebel⁸²⁰, Anbissa Muleta Senbeta⁸²¹, Subramanian Senthilkumaran⁸²², Seyedmojtaba Seyedmousavi⁸²³, Faramarz Shaahmadi⁸²⁴, Omid Shafaat¹³⁷⁵, Saeed Shahabi⁸²⁵, Masood Ali Shaikh⁸²⁶, Ali S. Shalash⁸²⁷, Mehran Shams-Beyranvand⁸²⁸, Amir Shamshirian⁸²⁹, Morteza Shamsizadeh⁸³⁰, Mohammed Shannawaz⁸³¹, Kiomars Sharafi⁷⁵, Mehdi Sharif^{832,833}, Rajesh Sharma⁸³⁴, Hatem Samir Shehata⁸, Abbas Sheikhtaheri^{69,835}, Kenji Shibuya⁸³⁶, Wondimeneh Shibabaw Shiferaw¹³¹, Mika Shigematsu⁸³⁷, Jae Il Shin^{838,839}, Rahman Shiri⁸⁴⁰, Reza Shirkoohi^{841,842}, Ivy Shiue⁸⁴³, Kerem Shuval⁵⁵⁶, Soraya Siabani^{844,845}, Tariq J. Siddiqi⁵⁰², Inga Dora Sigfusdottir^{846,847}, Diego Augusto Santos Silva⁸⁴⁸, Biagio Simonetti⁸⁴⁹, Ambrish Singh^{850,851}, Pushpendra Singh⁸⁵², Virendra Singh⁸⁵³, Jasvinder A. Singh^{854,855}, Pankaj Kumar Singh⁸⁵⁶, Dhirendra Narain Sinha^{857,858}, Yitagesu Sintayehu⁸⁵⁹, Malede Mequanent M. Sisay^{53,860}, Amin Soheili^{861,862}, Bija Soleymani⁴⁰⁶, Farzaneh Soltani⁸⁶³, Shahin Soltani⁸⁶⁴, Joan B. Soriano^{865,866}, Muluken Bekele Sorrie¹⁶⁴, Sergey Soshnikov^{867,868}, Ireneous N. Soyiri^{869,870}, Adel Spotin⁸⁷¹, Chandrashekhar T. Sreeramareddy⁸⁷², Rajni Kant Kant Srivastava⁸⁷³, Antonina Starodubova^{874,875}, Agus Sudaryanto^{876,877}, Mu'awiyah Babale Sufiyan⁸⁷⁸, Hafiz Ansar Rasul Suleria⁸⁷⁹, Gerhard Sulo⁸⁸⁰, Bruno F. Sunguya^{881,882}, Bryan L. Sykes⁸⁸³, Rafael Tabarés-Seisdedos^{884,885}, Takahiro Tabuchi⁸⁸⁶, Birkneh Tilahun Tadesse^{887,888}, Amir Taherkhani⁸⁸⁹, Koku Sisay Tamirat⁵³, Segen Gebremeskel Tassew⁸⁹⁰, Nuno Taveira^{891,892}, Berhane Fseha Teklehaimanot⁸⁹³, Gebretsadkan Hintsa Tekulu⁸⁹⁴, Mohamad-Hani Temsah^{895,896}, Abdullah Sulieman Terkawi^{897,898}, Zemenu Tadesse Tessema⁵³, Nihal Thomas⁸⁹⁹, Mariya Vladimirovna Titova^{331,900}, Kenean Getaneh Tlaye²⁴⁷, Hamid Reza Tohidinik^{420,901}, Marcello Tonelli⁹⁰², Marcos Roberto Tovani-Palone⁹⁰³, Eugenio Traini⁹⁰⁴, Khanh Bao Tran^{905,906}, Manjari Tripathi⁹⁰⁷, Riaz Uddin^{496,908}, Irfan Ullah^{909,910}, Bhaskaran Unnikrishnan⁴⁶⁸, Era Upadhyay⁹¹¹, Ushotanefe Useh⁹¹², Muhammad Shariq Usman⁵⁰², Olalekan A. Uthman⁹¹³, Marco Vacante¹⁹³, Masoud Vaezghasemi⁹¹⁴, Pascual R. Valdez^{915,916}, John VanderHeide¹, Elena Varavikova⁹¹⁷, Santosh Varughese⁹¹⁸, Tommi Juhani Vasankari⁹¹⁹, Yasser Vasseghian⁷⁵, Yousef Veisani⁹²⁰, Srinivasaraghavan Venkatesh⁹²¹, Narayanaswamy Venketasubramanian^{922,923}, Madhur Verma⁹²⁴, Simone Vidale⁹²⁵, Francesco S. Violante^{312,926}, Vasily Vlassov⁹²⁷, Sebastian Vollmer^{751,928}, Rade Vukovic^{929,930}, Yasir Waheed⁹³¹, Haidong Wang^{1,2}, Yafeng Wang⁹³², Yuan-Pang Wang²¹⁴, Girmay Teklay Weldesamuel¹²⁰, Andrea Werdecker^{651,933}, Taweewat Wiangkham⁹³⁴, Kirsten E. Wiens¹, Tissa Wijeratne^{935,936}, Haileab Fekadu Wolde⁵³, Dawit Zewdu Wondafrash^{937,938}, Tewodros Eshete Wonde⁴⁹⁰, Adam Belay Wondmieneh^{340,939}, Ai-Min Wu⁹⁴⁰, Gelin Xu⁹⁴¹, Abbas Yadegar⁶¹⁴, Ali Yadollahpour⁹⁴², Seyed Hossein Yahyazadeh Jabbari⁹⁴³, Tomohide Yamada⁹⁴⁴, Yuichiro Yano⁹⁴⁵, Sanni Yaya⁹⁴⁶, Vahid Yazdi-Feyzabadi^{947,948}, Alex Yeshaneh⁹⁴⁹, Yigizie Yeshaw⁵³, Yordanos Gizachew Yeshitila³⁴⁴, Mekdes Tigistu Yilma⁷⁸², Paul Yip^{950,951}, Naohiro Yonemoto⁹⁵², Seok-Jun Yoon⁹⁵³, Yoosik Youm⁹⁵⁴, Mustafa Z. Younis^{955,956}, Zabihollah Yousefi^{957,958}, Hebat-Allah Salah A. Yousof⁵⁰⁶, Chuanhua Yu^{932,959}, Hasan Yusefzadeh⁶⁸, Telma Zahirian Moghadam^{69,960}, Leila Zaki³⁴⁶, Sojib Bin Zaman^{431,961}, Mohammad Zamani⁹⁶²,

**Maryam Zamanian⁷⁶, Hamed Zandian^{960,963}, Hadi Zarafshan⁹⁶⁴, Nejimu Biza Zepro^{184,339},
Taddese Alemu Zerfu^{965,966}, Taye Abuhay Zewale⁹⁸, Yunquan Zhang^{967,968}, Zhi-Jiang Zhang⁹⁶⁹,
Xiu-Ju Zhao⁹⁷⁰, Sanjay Zodpey¹²⁷, Kamiar Zomorodian⁷⁰⁶, Francis Bruno Zotor⁵³⁰, Ashkan Afshin^{1,2} and
Simon I. Hay^{1,2} ✉**

¹Institute for Health Metrics and Evaluation, University of Washington, Seattle, WA, USA. ²Department of Health Metrics Sciences, School of Medicine, University of Washington, Seattle, WA, USA. ³Department of Global Health, University of Washington, Seattle, WA, USA. ⁴Department of Medicine, University of Washington, Seattle, WA, USA. ⁵School of Nutrition and Food Sciences, Tabriz University of Medical Sciences, Tabriz, Iran. ⁶Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁷Advanced Diagnostic and Interventional Radiology Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁸Department of Neurology, Cairo University, Cairo, Egypt. ⁹Department of Parasitology and Mycology, Jahrom University of Medical Sciences, Jahrom, Iran. ¹⁰The Institute of Pharmaceutical Sciences (TIPS), Toxicology and Diseases Group, Tehran University of Medical Sciences, Tehran, Iran. ¹¹Neuroscience Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. ¹²Department of Public Health, Ministry of Health, Riyadh, Saudi Arabia. ¹³School of Public Health, Addis Ababa University, Addis Ababa, Ethiopia. ¹⁴Public Health, Wachemo University, Hosanna, Ethiopia. ¹⁵College of Medicine and Health Sciences, Hawassa University, Hawassa, Ethiopia. ¹⁶Biostatistics and Health Informatics, Madda Walabu University, Bale Robe, Ethiopia. ¹⁷Radiotherapy Center, Addis Ababa University, Addis Ababa, Ethiopia. ¹⁸LABMED, Karolinska University Hospital, Huddinge, Sweden. ¹⁹Research Center for Immunodeficiencies, Tehran University of Medical Sciences, Tehran, Iran. ²⁰Department of Pediatric Dentistry, Federal University of Minas Gerais, Belo Horizonte, Brazil. ²¹Research Department, Philippine Institute for Development Studies, Quezon City, Philippines. ²²Cardiovascular Medicine, Ain Shams University, Abbasia, Egypt. ²³Bénin Clinical Research Institute (IRCB), Cotonou, Benin. ²⁴Department of Preventive Medicine, Dongguk University, Gyeongju, South Korea. ²⁵Department of Community Medicine, Kathmandu University, Devdaha, Nepal. ²⁶Hamadan University of Medical Sciences, Hamadan, Iran. ²⁷Department of Community Medicine, University of Ibadan, Ibadan, Nigeria. ²⁸Department of Community Medicine, University College Hospital, Ibadan, Ibadan, Nigeria. ²⁹Department of Sociology, Olabisi Onabanjo University, Ago-Iwoye, Nigeria. ³⁰School of Medicine, Cardiff University, Cardiff, UK. ³¹College of Medicine, University of Ibadan, Ibadan, Nigeria. ³²Community Cardiovascular Research Unit, Elyon Heart Rehabilitation Center, Ibadan, Nigeria. ³³Department of Global Health, Stellenbosch University, Stellenbosch, South Africa. ³⁴Cochrane South Africa, South African Medical Research Council, Cape Town, South Africa. ³⁵School of Health, Ardabil University of Medical Science, Ardabil, Iran. ³⁶Department of Health Promotion and Education, University of Ibadan, Ibadan, Nigeria. ³⁷Social Behavioral Research Branch, National Institute of Health, Bethesda, MD, USA. ³⁸Cancer Prevention and Control, Georgetown University, Washington, DC, USA. ³⁹Endocrinology and Metabolism Research Center (EMRC), Tehran University of Medical Sciences, Tehran, Iran. ⁴⁰Epidemiology, Qom University of Medical Sciences, Qom, Iran. ⁴¹Research Area for Informatics and Big Data, CSIR Institute of Genomics and Integrative Biology, Delhi, India. ⁴²Department of Internal Medicine, Baylor College of Medicine, Houston, TX, USA. ⁴³Department of Epidemiology and Health Statistics, School of Public Health, Southeast University Nanjing, Nanjing, China. ⁴⁴Microbiology Department, Hazara University Mansehra, Mansehra, Pakistan. ⁴⁵Lincoln Medical School, Universities of Nottingham & Lincoln, Lincoln, UK. ⁴⁶School of Advanced Technologies in Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁴⁷Department of Epidemiology, Jimma University, Jimma, Ethiopia. ⁴⁸James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh. ⁴⁹Health Systems and Population Studies Division, International Centre for Diarrhoeal Disease Research, Bangladesh, Dhaka, Bangladesh. ⁵⁰School of Community Health Sciences, University of Nevada, Reno, NV, USA. ⁵¹National Malaria Elimination Program, Federal Ministry of Health, Abuja, Nigeria. ⁵²Department of Medical Laboratory Sciences, Bahir Dar University, Bahir Dar, Ethiopia. ⁵³Department of Epidemiology and Biostatistics, University of Gondar, Gondar, Ethiopia. ⁵⁴Department of Population Health Sciences, Duke University, Durham, NC, USA. ⁵⁵Duke Global Health Institute, Duke University, Durham, NC, USA. ⁵⁶School of Public Health and Community Medicine, University of New South Wales, Sydney, New South Wales, Australia. ⁵⁷John T. Milliken Department of Internal Medicine, Washington University in St. Louis, St Louis, MO, USA. ⁵⁸Clinical Epidemiology Center, VA Saint Louis Health Care System, Department of Veterans Affairs, St Louis, MO, USA. ⁵⁹Department of Medicine, Dalhousie University, Halifax, NS, Canada. ⁶⁰School of Health Sciences, Madda Walabu University, Bale Goba, Ethiopia. ⁶¹Department of Health Information Management and Technology, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia. ⁶²Centre of Health System Research, National Institute of Public Health, Cuernavaca, Mexico. ⁶³Department of Pharmacy, Adigrat University, Adigrat, Ethiopia. ⁶⁴Medical Technical Institute, Erbil Polytechnic University, Erbil, Iraq. ⁶⁵Ishik University, Erbil, Iraq. ⁶⁶Department of Biotechnology, Quaid-i-Azam University Islamabad, Islamabad, Pakistan. ⁶⁷Social Determinants of Health Research Center, Qazvin University of Medical Sciences, Qazvin, Iran. ⁶⁸Department of Health Care Management and Economics, Urmia University of Medical Science, Urmia, Iran. ⁶⁹Health Management and Economics Research Center, Iran University of Medical Sciences, Tehran, Iran. ⁷⁰Health Economics Department, Iran University of Medical Sciences, Tehran, Iran. ⁷¹Department of Microbiology, Kerman University of Medical Sciences, Kerman, Iran. ⁷²Department of Microbiology, Hormozgan University of Medical Sciences, Bandar Abbas, Iran. ⁷³Department of Health Policy and Management, Kuwait University, Safat, Kuwait. ⁷⁴International Centre for Casemix and Clinical Coding, National University of Malaysia, Bandar Tun Razak, Malaysia. ⁷⁵Research Center for Environmental Determinants of Health (RCEDH), Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁷⁶Department of Epidemiology, Arak University of Medical Sciences, Arak, Iran. ⁷⁷Medical Research Center, Jazan University, Jazan, Saudi Arabia. ⁷⁸Department of Medical Parasitology, Sana'a University, Sana'a, Yemen. ⁷⁹Department of Family and Community Medicine, King Abdulaziz University, Jeddah, Saudi Arabia. ⁸⁰King Saud University, Riyadh, Saudi Arabia. ⁸¹Research Group in Health Economics, University of Cartagena, Cartagena, Colombia. ⁸²Research Group in Hospital Management and Health Policies, University of the Coast, Barranquilla, Colombia. ⁸³Departamento de Ciencias Económicas, Universidad de la Costa, Barranquilla, Colombia. ⁸⁴Observatorio Nacional de Salud, National Institute of Health, Bogotá, Colombia. ⁸⁵Sansom Institute, South Australian Health and Medical Research Institute, Adelaide, South Australia, Australia. ⁸⁶Bahir Dar University, Bahir Dar, Ethiopia. ⁸⁷Biomedical Science, University of Cape Coast, Cape Coast, Ghana. ⁸⁸Health Services Management Department, Arak University of Medical Sciences, Arak, Iran. ⁸⁹Health Services Management, Isfahan University of Medical Sciences, Isfahan, Iran. ⁹⁰Department of Radiology, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁹¹Department of Epidemiology and Biostatistics, University of the Philippines Manila, Manila, Philippines. ⁹²Online Programs for Applied Learning, Johns Hopkins University, Baltimore, MD, USA. ⁹³Mansoura University, Mansoura, Egypt. ⁹⁴Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. ⁹⁵Research Center for Evidence Based Medicine-Health Management and Safety Promotion Research Institute, Tabriz University of Medical Sciences, Tabriz, Iran. ⁹⁶Razi Vaccine and Serum Research Institute, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran. ⁹⁷Department of Epidemiology and Biostatistics, Health Promotion Research Center, Zahedan, Iran. ⁹⁸Department of Epidemiology and Biostatistics, Bahir Dar University, Bahir Dar, Ethiopia. ⁹⁹Department of Health Policy and Administration, University of the Philippines Manila, Manila, Philippines. ¹⁰⁰Department of Applied Social Sciences, Hong Kong Polytechnic University, Hong Kong, China. ¹⁰¹Department of Agribusiness, Universitas Sebelas Maret, Surakarta, Indonesia. ¹⁰²Department of Parasitology, Mazandaran University of Medical Sciences, Sari, Iran. ¹⁰³Department of Microbiology and Immunology, Iranshahr University of Medical Sciences, Iranshahr, Iran. ¹⁰⁴Department of Pathology, Al-Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia. ¹⁰⁵Department of Sociology and Social Work, Kwame Nkrumah

University of Science and Technology, Kumasi, Ghana.¹⁰⁶Center for International Health, Ludwig Maximilians University, Munich, Germany.¹⁰⁷Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran.¹⁰⁸Department of Health Promotion and Education, Tehran University of Medical Sciences, Tehran, Iran.¹⁰⁹School of Health Sciences, Birmingham City University, Birmingham, UK.¹¹⁰Department of Neurobiology, Karolinska Institutet, Stockholm, Sweden.¹¹¹School of Health and Social Studies, Dalarna University, Falun, Sweden.¹¹²School of Nursing and Midwife, Babol University of Medical Sciences, Babol, Iran.¹¹³Babol University of Medical Sciences, Babol, Iran.¹¹⁴Preventive Medicine and Public Health Research Center, Iran University of Medical Sciences, Tehran, Iran.¹¹⁵Neurology, Shiraz University of Medical Sciences, Shiraz, Iran.¹¹⁶Prevention of Metabolic Disorders Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.¹¹⁷Department of Microbiology, Hamedan University of Medical Sciences, Hamedan, Iran.¹¹⁸Department of Clinical Chemistry, University of Gondar, Gondar, Ethiopia.¹¹⁹Non-Communicable Diseases Research Center, Tehran University of Medical Sciences, Tehran, Iran.¹²⁰Department of Nursing, Aksum University, Aksum, Ethiopia.¹²¹Department of Health System and Health Economics, Bahir Dar University, Bahir Dar City, Ethiopia.¹²²School of Nursing, , University of Nottingham, Amman, Jordan.¹²³School of Business, University of Leicester, Leicester, UK.¹²⁴Department of Statistics and Econometrics, Bucharest University of Economic Studies, Bucharest, Romania.¹²⁵Bénin Clinical Research Institute (IRCB), Abomey-Calavi, Benin.¹²⁶Contrôle des Maladies Infectieuses, Laboratory of Studies and Research-Action in Health, Porto Novo, Benin.¹²⁷Indian Institute of Public Health, Public Health Foundation of India, Gurugram, India.¹²⁸The Judith Lumley Centre, La Trobe University, Melbourne, Victoria, Australia.¹²⁹General Office for Research and Technological Transfer, Peruvian National Institute of Health, Lima, Peru.¹³⁰Department of Health Policy Planning and Management, University of Health and Allied Sciences, Ho, Ghana.¹³¹Department of Nursing, Debre Berhan University, Debre Berhan, Ethiopia.¹³²Cellular and Molecular Biology Research Center, Babol University of Medical Sciences, Babol, Iran.¹³³Department of Environmental Health Engineering, Hamadan University of Medical Sciences, Hamadan, Iran.¹³⁴Department of Reproductive Health, University of Gondar, Gondar, Ethiopia.¹³⁵Public Health Risk Sciences Division, Public Health Agency of Canada, Toronto, Ontario, Canada.¹³⁶Department of Nutritional Sciences, University of Toronto, Toronto, Ontario, Canada.¹³⁷Department of Forensic Science, Government Institute of Forensic Science, Nagpur, India.¹³⁸Healthcare Management Department, Shiraz University of Medical Sciences, Shiraz, Iran.¹³⁹Biochemistry Unit, Universiti Sultan Zainal Abidin, Kuala Terengganu, Malaysia.¹⁴⁰Biomedicine Department, Universiti Sultan Zainal Abidin Gongbedak, Kuala Terengganu, Malaysia.¹⁴¹Health Policy and Management Department, Tehran University of Medical Sciences, Tehran, Iran.¹⁴²Department of Forensic Medicine and Toxicology, , Manipal Academy of Higher Education, Manipal, India.¹⁴³Department of Medical Laboratory Science, Haramaya University, Harar, Ethiopia.¹⁴⁴School of Public Health, Haramaya University, Harar, Ethiopia.¹⁴⁵Department of Hypertension, Medical University of Lodz, Lodz, Poland.¹⁴⁶Polish Mothers' Memorial Hospital Research Institute, Lodz, Poland.¹⁴⁷Department of Noncommunicable Diseases, Bangladesh University of Health Sciences (BUHS), Dhaka, Bangladesh.¹⁴⁸Department of Animal Pathology and Epidemiology, Razi Vaccine and Serum Research Institute, Karaj, Iran.¹⁴⁹Department of Neurosciences, Costa Rican Department of Social Security, San Jose, Costa Rica.¹⁵⁰School of Medicine, University of Costa Rica, San Pedro, Costa Rica.¹⁵¹Heidelberg Institute of Global Health (HIGH), Heidelberg University, Heidelberg, Germany.¹⁵²T.H. Chan School of Public Health, Harvard University, Boston, MA, USA.¹⁵³University of Aden, Aden, Yemen.¹⁵⁴School of Public Health, Imperial College London, London, UK.¹⁵⁵Health Human Resources Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.¹⁵⁶Department of Applied Human Nutrition, Bahir Dar University, Bahir Dar, Ethiopia.¹⁵⁷University of Gondar, Gondar, Ethiopia.¹⁵⁸Department of Community Medicine, Gandhi Medical College Bhopal, Bhopal, India.¹⁵⁹Jazan University, Jazan, Saudi Arabia.¹⁶⁰Social Determinants of Health Research Center, Lorestan University of Medical Sciences, Khorramabad, Iran.¹⁶¹Department of Epidemiology and Biostatistics, Lorestan University of Medical Sciences, Khorramabad, Iran.¹⁶²Department of Reproductive Health and Population Studies, Bahir Dar University, Bahir Dar, Ethiopia.¹⁶³Nuffield Department of Population Health, University of Oxford, Oxford, UK.¹⁶⁴Department of Public Health, Arba Minch University, Arba Minch, Ethiopia.¹⁶⁵Department of Nutrition and Dietetics, Mekelle University, Mekelle, Ethiopia.¹⁶⁶Adigrat University, Adigrat, Ethiopia.¹⁶⁷School of Public Health, Wolaita Sodo University, Addis Ababa, Ethiopia.¹⁶⁸Department of Medicine, Medical College of Georgia at Augusta University, Augusta, GA, USA.¹⁶⁹Hubert Department of Global Health, Emory University, Atlanta, GA, USA.¹⁷⁰Department of Global Health, University of South Florida, Tampa, FL, USA.¹⁷¹Department of Health Information Management, Manipal Academy of Higher Education, Manipal, Manipal, India.¹⁷²School of Public Health, University of Adelaide, Adelaide, South Australia, Australia.¹⁷³Public Health Research Laboratory, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal.¹⁷⁴Department of Community Medicine and Family Medicine, All India Institute of Medical Sciences, Jodhpur, India.¹⁷⁵Department of Community Medicine, Datta Meghe Institute of Medical Sciences, Deemed University, Wardha, India.¹⁷⁶Department of Statistical and Computational Genomics, National Institute of Biomedical Genomics, Kalyani, India.¹⁷⁷Department of Statistics, University of Calcutta, Kolkata, India.¹⁷⁸Social Determinants of Health Research Center, Babol University of Medical Sciences, Babol, Iran.¹⁷⁹Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Ranica, Italy.¹⁸⁰Health Economics & Outcomes Research, Creativ-Ceutical (Huntsworth Health), London, UK.¹⁸¹Woldia University, Woldia, Ethiopia.¹⁸²National Centre for Epidemiology and Population Health, Australian National University, Canberra, Australian Capital Territory, Australia.¹⁸³Department of Clinical Pharmacy and Pharmacology, University of Dhaka, Dhaka, Bangladesh.¹⁸⁴Department of Public Health, Samara University, Samara, Ethiopia.¹⁸⁵Debretabor University, Addis Ababa University, Debretabor, Ethiopia.¹⁸⁶Department of Pediatrics and Child Health Nursing, Bahir Dar University, Bahir Dar, Ethiopia.¹⁸⁷Transport and Road Safety (TARS) Research Center, , University of New South Wales, Sydney, New South Wales, Australia.¹⁸⁸School of Health Sciences, Swinburne University of Technology, Melbourne, Victoria, Australia.¹⁸⁹Department of Nutrition, Saint Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia.¹⁹⁰Department of Veterinary Medicine, Islamic Azad University, Kermanshah, Iran.¹⁹¹Department of Biomedical Sciences, Nazarbayev University, Nur-Sultan City, Kazakhstan.¹⁹²Department of Internal Medicine, Manipal Academy of Higher Education, Mangalore, India.¹⁹³Department of General Surgery and Medical-Surgical Specialties, University of Catania, Catania, Italy.¹⁹⁴School of Medicine, Hamadan University of Medical Sciences, Hamadan, Iran.¹⁹⁵Department of Infectious Disease Epidemiology, London School of Hygiene & Tropical Medicine, London, UK.¹⁹⁶University of Genoa, Genoa, Italy.¹⁹⁷Division of Hematology and Oncology, Georgetown University, Washington, DC, USA.¹⁹⁸Epidemiology and Evidence Based Medicine, I.M. Sechenov First Moscow State Medical University, Moscow, Russia.¹⁹⁹Gorgas Memorial Institute for Health Studies, Panama City, Panama.²⁰⁰Department of Research, Golden Community, Kathmandu, Nepal.²⁰¹Department of Community Medicine, Employees' State Insurance Model Hospital, Bangalore, India.²⁰²Department for Health Care Management, Technical University of Berlin, Berlin, Germany.²⁰³School of Public Health and Health Systems, University of Waterloo, Waterloo, Ontario, Canada.²⁰⁴Al Shifa School of Public Health, Al Shifa Trust Eye Hospital, Rawalpindi, Pakistan.²⁰⁵Internal Medicine Department, Hospital Italiano de Buenos Aires, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina.²⁰⁶Comisión Directiva, Argentine Society of Medicine, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina.²⁰⁷National Institute of Public Health, Cuernavaca, Mexico.²⁰⁸Department of Disease Control, London School of Hygiene & Tropical Medicine, London, UK.²⁰⁹Centre for Population Health Sciences, Nanyang Technological University, Singapore, Singapore.²¹⁰Global eHealth Unit, Imperial College London, London, UK.²¹¹Department of Population and Health, Metropolitan Autonomous University, Mexico City, Mexico.²¹²Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden.²¹³Research Unit on Applied Molecular Biosciences (UCIBIO), University of Porto, Porto, Portugal.²¹⁴Department of Psychiatry, University of São Paulo, São Paulo, Brazil.²¹⁵Colombian National Health Observatory, National Institute of Health, Bogota, Colombia.²¹⁶Epidemiology and Public Health Evaluation Group, National University of Colombia, Bogota, Colombia.²¹⁷Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Victoria, Australia.²¹⁸School of Public Health, University of Hong Kong, Hong Kong, China.²¹⁹Health, Nutrition and Population, World Bank, Lusaka, Zambia.²²⁰Institute for Global Health, Heidelberg University, Heidelberg, Germany.²²¹Department of Pharmacology, All India Institute of Medical Sciences, Jodhpur, India.²²²Division of Epidemiology, National Institute of Cholera and Enteric Diseases, Kolkata, India.²²³Department of Medicine, University of Toronto, Toronto,

Ontario, Canada. ²²⁴Population Research Centre, Gokhale Institute of Politics and Economics, Pune, India. ²²⁵International Institute for Population Sciences, Mumbai, India. ²²⁶Department of Medical Entomology and Vector Control, Urmia University of Medical Science, Urmia, Iran. ²²⁷Department of Biostatistics and Epidemiology, Babol University of Medical Sciences, Babol, Iran. ²²⁸Epidemiology Research Center, Royan Institute, Tehran, Iran. ²²⁹Department of Nursing, Wolaita Sodo University, Sodo, Ethiopia. ²³⁰Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia. ²³¹Department of Pulmonary Medicine, Christian Medical College and Hospital (CMC), Vellore, India. ²³²Hanoi National University of Education, Hanoi, Vietnam. ²³³School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia. ²³⁴School of Medicine and Surgery, University of Milan Bicocca, Monza, Italy. ²³⁵Institute of Public Health, University of Gondar, Gondar, Ethiopia. ²³⁶Discipline of Public Health, Flinders University, Adelaide, South Australia, Australia. ²³⁷Department of Human Physiology, University of Gondar, Gondar, Ethiopia. ²³⁸Department of Environmental Health, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia. ²³⁹Department of Dermatology, Case Western Reserve University, Cleveland, OH, USA. ²⁴⁰Department of Dermatology, University of Milan, Milan, Italy. ²⁴¹Department of Pediatrics, Tanta University, Tanta, Egypt. ²⁴²Toxoplasmosis Research Center, Mazandaran University of Medical Sciences, Sari, Iran. ²⁴³Division of Women and Child Health, Aga Khan University, Karachi, Pakistan. ²⁴⁴Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA. ²⁴⁵Population and Development, Facultad Latinoamericana de Ciencias Sociales Mexico, Mexico City, Mexico. ²⁴⁶Australian Institute for Suicide Research and Prevention, Griffith University, Mount Gravatt, Queensland, Australia. ²⁴⁷Department of Nursing, Woldia University, Woldia, Ethiopia. ²⁴⁸Department of Nursing, Jimma University, Jimma, Ethiopia. ²⁴⁹Department of Neonatal Nursing, St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia. ²⁵⁰Ambo University, Ambo, Ethiopia. ²⁵¹School of Pharmacy, Aksum University, Aksum, Ethiopia. ²⁵²Addis Ababa University, Addis Ababa, Ethiopia. ²⁵³Center for Nutrition and Health Research, National Institute of Public Health, Cuernavaca, Mexico. ²⁵⁴Department of Global Health and Infection, Brighton and Sussex Medical School, Brighton, UK. ²⁵⁵Division of Cardiology, Atlanta Veterans Affairs Medical Center, Decatur, GA, USA. ²⁵⁶School of Nutrition, Food Science and Technology, Hawassa University, Hawassa, Ethiopia. ²⁵⁷School of Nursing and Midwifery, Haramaya University, Harar, Ethiopia. ²⁵⁸Centre for Atmospheric Sciences, Indian Institute of Technology Delhi, New Delhi, India. ²⁵⁹Department of Community Medicine, University of Peradeniya, Peradeniya, Sri Lanka. ²⁶⁰Mathematical Demography and Statistics, International Institute for Population Sciences, Mumbai, India. ²⁶¹Health Research Section, Nepal Health Research Council, Kathmandu, Nepal. ²⁶²Department of Microbiology, Far Western University, Mahendranagar, Nepal. ²⁶³Department of Epidemiology, Shiraz University of Medical Sciences, Shiraz, Iran. ²⁶⁴Center of Complexity Sciences, National Autonomous University of Mexico, Mexico City, Mexico. ²⁶⁵Facultad de Medicina Veterinaria y Zootecnia, Autonomous University of Sinaloa, Culiacan, Mexico. ²⁶⁶Department of Nursing, Bank Mellé, Tehran, Iran. ²⁶⁷Fenot Project, Harvard University, Addis Ababa, Ethiopia. ²⁶⁸Ministry of Health and Medical Education, Tehran, Iran. ²⁶⁹Center of Excellence in Public Health Nutrition, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam. ²⁷⁰Center of Excellence in Behavioral Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam. ²⁷¹School of Nursing and Midwifery, University of Cape Coast, Cape Coast, Ghana. ²⁷²Iran University of Medical Sciences, Tehran, Iran. ²⁷³Department of Health Policy and Economy, Tabriz University of Medical Sciences, Tabriz, Iran. ²⁷⁴World Food Programme, New Delhi, India. ²⁷⁵Public Health Department, Hawassa University, Hawassa, Ethiopia. ²⁷⁶Curtin University, Perth, Western Australia, Australia. ²⁷⁷Centre for Tropical Medicine and Global Health, University of Oxford, Oxford, UK. ²⁷⁸Mahidol-Oxford Tropical Medicine Research Unit, Bangkok, Thailand. ²⁷⁹Postgraduate Program in Epidemiology, Federal University of Rio Grande do Sul, Porto Alegre, Brazil. ²⁸⁰School of Medicine, Federal University of Bahia, Salvador, Brazil. ²⁸¹Medicina Interna, Escola Bahiana de Medicina e Saúde Pública, Salvador, Brazil. ²⁸²Department of Bacteriology and Virology, Tabriz University of Medical Sciences, Tabriz, Iran. ²⁸³Department of Pharmacology and Toxicology, Maragheh University of Medical Sciences, Maragheh, Iran. ²⁸⁴Department of Pharmacology and Toxicology, Tabriz University of Medical Sciences, Tabriz, Iran. ²⁸⁵Biomedical Informatics and Medical Statistics, Alexandria University, Alexandria, Egypt. ²⁸⁶Department of Clinical Pathology, Mansoura University, Mansoura, Egypt. ²⁸⁷Pediatric Dentistry and Dental Public Health, Alexandria University, Alexandria, Egypt. ²⁸⁸Institute of Public Health, United Arab Emirates University, Al Ain, United Arab Emirates. ²⁸⁹Department of Statistics, Debre Markos University, Debre Markos, Ethiopia. ²⁹⁰Department of Public Health Sciences, Karolinska Institutet, Stockholm, Sweden. ²⁹¹World Health Programme, Université du Québec en Abitibi-Témiscamingue, Rouyn-Noranda, Quebec, Canada. ²⁹²Endemic Medicine and Hepatogastroenterology Department, Cairo University, Cairo, Egypt. ²⁹³Department of Biosciences, Nottingham Trent University, Nottingham, UK. ²⁹⁴Eijkman-Oxford Clinical Research Unit, Eijkman Institute for Molecular Biology, Jakarta, Indonesia. ²⁹⁵Ophthalmic Epidemiology Research Center, Shahroud University of Medical Sciences, Shahroud, Iran. ²⁹⁶Department of Microbiology and Immunology, Suez Canal University, Ismailia, Egypt. ²⁹⁷Department of Midwifery, Wolkite University, Wolkite, Ethiopia. ²⁹⁸Department of Midwifery, Woldia University, Woldia, Ethiopia. ²⁹⁹Department of Medicinal Chemistry, Kerman University of Medical Sciences, Kerman, Iran. ³⁰⁰Pharmaceutics Research Center, Kerman University of Medical Sciences, Kerman, Iran. ³⁰¹Multiple Sclerosis Research Center, Tehran University of Medical Sciences, Tehran, Iran. ³⁰²Department of Physiology, Tarbiat Modares University, Tehran, Iran. ³⁰³Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, MD, USA. ³⁰⁴Tehran University of Medical Sciences, Tehran, Iran. ³⁰⁵Unit of Medical Physiology, Hawassa University, Hawassa, Ethiopia. ³⁰⁶Berman Institute of Bioethics, Johns Hopkins University, Baltimore, MD, USA. ³⁰⁷Nutrition and Food Systems Division, Food and Agriculture Organization of the United Nations, Rome, Italy. ³⁰⁸School of Public Health, Tehran University of Medical Sciences, Tehran, Iran. ³⁰⁹Department of Political Science, University of Human Development, Sulaimaniyah, Iraq. ³¹⁰Deputy of Research and Technology, Hamadan University of Medical Sciences, Hamadan, Iran. ³¹¹College of Medicine, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia. ³¹²Department of Medical and Surgical Sciences, University of Bologna, Bologna, Italy. ³¹³Department of Psychology, Federal University of Sergipe, Sao Cristovao, Brazil. ³¹⁴Department of Biological and Biomedical Sciences, Aga Khan University, Karachi, Pakistan. ³¹⁵College of Medicine and Public Health, Flinders University, Adelaide, South Australia, Australia. ³¹⁶Institute of Resource Governance and Social Change, Kupang, Indonesia. ³¹⁷Social Determinants of Health Research Center, Hamadan University of Medical Sciences, Hamadan, Iran. ³¹⁸Department of Public Health Nutrition, Bahir Dar University, Bahir Dar, Ethiopia. ³¹⁹School of Nursing and Midwifery, Hawassa University, Hawassa, Ethiopia. ³²⁰Division of Neurology, University of Ottawa, Ottawa, Ontario, Canada. ³²¹REQUIMTE/LAQV - Network of Chemistry and Technology, University of Porto, Porto, Portugal. ³²²Center for Biotechnology and Fine Chemistry, Catholic University of Portugal, Porto, Portugal. ³²³Department of Health Education & Behavioral Sciences, Jimma University, Jimma, Ethiopia. ³²⁴Jimma University, Jimma, Ethiopia. ³²⁵Psychiatry Department, Kaiser Permanente, Fontana, CA, USA. ³²⁶School of Health Sciences, A.T. Still University, Mesa, AZ, USA. ³²⁷Department of Population Medicine and Health Services Research, Bielefeld University, Bielefeld, Germany. ³²⁸Unit for Population-Based Dermatology Research, King's College London, London, UK. ³²⁹Institute of Gerontology, National Academy of Medical Sciences of Ukraine, Kyiv, Ukraine. ³³⁰Department of Child Dental Health, Obafemi Awolowo University, Ile-Ife, Nigeria. ³³¹Timiryazev Institute of Plant Physiology (IPPRAS), Russian Academy of Sciences, Moscow, Russia. ³³²Abadan School of Medical Sciences, Abadan University of Medical Sciences, Abadan, Iran. ³³³Department of Research, Center for Population and Health, Wiesbaden, Germany. ³³⁴Department of Family Medicine and Primary Care, University of the Witwatersrand, Johannesburg, South Africa. ³³⁵Department of Dermatology, Kobe University, Kobe, Japan. ³³⁶Gene Expression & Regulation Program, The Wistar Institute, Philadelphia, PA, USA. ³³⁷School of Nursing and Midwifery, Wollega University, Nekemte, Ethiopia. ³³⁸Public Health Department, Madda Walabu University, Bale-Robe, Ethiopia. ³³⁹School of Public Health, Mekelle University, Mekelle, Ethiopia. ³⁴⁰Department of Nursing and Midwifery, Addis Ababa University, Addis Ababa, Ethiopia. ³⁴¹Nursing Department, Mekelle University, Mekelle, Ethiopia. ³⁴²Haramaya University, Dire Dawa, Ethiopia. ³⁴³Pharmacy, Wollo University, Dessie, Ethiopia. ³⁴⁴Department of Nursing, Arba Minch University, Arba Minch, Ethiopia. ³⁴⁵Department of Biostatistics, Mekelle University, Mekelle, Ethiopia. ³⁴⁶Department of Parasitology and Entomology, Tarbiat Modares University, Tehran, Iran. ³⁴⁷Department of Medical Surgery, Tabriz University of Medical Sciences, Tabriz, Iran. ³⁴⁸Department of Medicine,

Massachusetts General Hospital, Boston, MA, USA. ³⁴⁹Neuroscience Institute, Academy of Medical Science, Tehran, Iran. ³⁵⁰Department of Health Services Management, Iran University of Medical Sciences, Tehran, Iran. ³⁵¹Social Determinants of Health Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. ³⁵²Science and Research Branch, Islamic Azad University, Tehran, Iran. ³⁵³Young Researchers and Elite Club, Islamic Azad University, Rasht, Iran. ³⁵⁴University of Lahore, Lahore, Pakistan. ³⁵⁵Afro-Asian Institute, Lahore, Pakistan. ³⁵⁶Adelaide Medical School, University of Adelaide, Adelaide, South Australia, Australia. ³⁵⁷Department of Family and Community Medicine, University of Hail, Hail, Saudi Arabia. ³⁵⁸Center for the Study of Regional Development, Jawahar Lal Nehru University, New Delhi, India. ³⁵⁹Department of Chemistry, University of Porto, Porto, Portugal. ³⁶⁰Department of Biostatistics and Epidemiology, University of Oklahoma, Oklahoma City, OK, USA. ³⁶¹Department of Health and Social Affairs, Government of the Federated States of Micronesia, Palikir, Federated States of Micronesia. ³⁶²Department of Respiratory Medicine, Hokkaido University, Sapporo, Japan. ³⁶³Center for Environmental and Health Sciences, Hokkaido University, Sapporo, Japan. ³⁶⁴Center for Clinical and Epidemiological Research, University of São Paulo, Sao Paulo, Brazil. ³⁶⁵Internal Medicine Department, University of São Paulo, São Paulo, Brazil. ³⁶⁶Manipal Institute of Virology, Manipal Academy of Higher Education, Manipal, India. ³⁶⁷Department of Dermatology, Boston University, Boston, MA, USA. ³⁶⁸Instituto de Patologia Tropical e Saúde Pública, Federal University of Goiás, Goiânia, Brazil. ³⁶⁹College of Medicine and Health Science, Jigjiga University, Jigjiga, Ethiopia. ³⁷⁰Department of Epidemiology and Biostatistics, Zhengzhou University, Zhengzhou, China. ³⁷¹March of Dimes, Arlington, VA, USA. ³⁷²School of Public Health, West Virginia University Morgantown, Morgantown, WV, USA. ³⁷³Academics and Research Department, Rajasthan University of Health Sciences, Jaipur, India. ³⁷⁴Department of Medicine, Mahatma Gandhi University of Medical Sciences & Technology, Jaipur, India. ³⁷⁵Department of Radiology and Radiological Sciences, Johns Hopkins University, Baltimore, MD, USA. ³⁷⁶School of Medicine, Tehran University of Medical Sciences, Tehran, Iran. ³⁷⁷Department of Nursing, St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia. ³⁷⁸Department of Pharmacology, Tehran University of Medical Sciences, Tehran, Iran. ³⁷⁹Obesity Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ³⁸⁰Global and Community Mental Health Research Group, University of Macau, Macao, China. ³⁸¹Department of Anatomical Sciences, Tarbiat Modares University, Tehran, Iran. ³⁸²Department of Family and Community Medicine, Arabian Gulf University, Manama, Bahrain. ³⁸³Department of Health Management and Economics, Hamadan University of Medical Sciences, Hamadan, Iran. ³⁸⁴School of Medicine, University of Western Australia, Perth, Western Australia, Australia. ³⁸⁵Neurology Department, Sir Charles Gairdner Hospital, Perth, Western Australia, Australia. ³⁸⁶Tabriz University of Medical Sciences, Tabriz, Iran. ³⁸⁷Department of Dental Public Health, Universitas Airlangga Indonesia, Surabaya, Indonesia. ³⁸⁸Australian Research Centre for Population Oral Health, University of Adelaide, Adelaide, South Australia, Australia. ³⁸⁹Department of Zoology, Al-Azhar University, Cairo, Egypt. ³⁹⁰Institute for Social Science Research, The University of Queensland, Indooroopilly, Queensland, Australia. ³⁹¹Department of Healthcare Management, Maragheh University of Medical Sciences, Maragheh, Iran. ³⁹²Department of Microbiology, Maragheh University of Medical Sciences, Maragheh, Iran. ³⁹³Department of Microbiology, Tehran University of Medical Sciences, Tehran, Iran. ³⁹⁴Department of Biology, Utica College, Utica, NY, USA. ³⁹⁵Gastrointestinal and Liver Disease Research Center, Guilan University of Medical Sciences, Rasht, Iran. ³⁹⁶Guilan University of Medical Sciences, Rasht, Iran. ³⁹⁷Department of Public Health, Mizan-Tepi University, Tepi, Ethiopia. ³⁹⁸Unit of Epidemiology and Social Medicine, University Hospital Antwerp, Wilrijk, Belgium. ³⁹⁹Department of Clinical Sciences, Karolinska University Hospital, Stockholm, Sweden. ⁴⁰⁰School of Health Sciences, City University of London, London, UK. ⁴⁰¹Institute of Pharmaceutical Sciences, University of Veterinary and Animal Sciences, Lahore, Pakistan. ⁴⁰²Department of Pharmacy Administration and Clinical Pharmacy, Xian Jiaotong University, Xian, China. ⁴⁰³Shahrekord University of Medical Sciences, Shahrekord, Iran. ⁴⁰⁴School of Public Health, Curtin University, Perth, Western Australia, Australia. ⁴⁰⁵Agriculture and Food, Commonwealth Scientific and Industrial Research Organisation, St. Lucia, Queensland, Australia. ⁴⁰⁶Medical Biology Research Center, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁴⁰⁷Department of Biostatistics and Epidemiology, Adigrat University, Adigrat, Ethiopia. ⁴⁰⁸Department of Psychiatry, University Medical Center Groningen, Groningen, the Netherlands. ⁴⁰⁹Department of Epidemiology, Columbia University, New York, NY, USA. ⁴¹⁰Department of Pediatrics, Dell Medical School, University of Texas Austin, Austin, TX, USA. ⁴¹¹Kasturba Medical College, Manipal Academy of Higher Education, Manipal, India. ⁴¹²Guilan Road Trauma Research Center, Guilan University of Medical Sciences, Rasht, Iran. ⁴¹³Social Determinants of Health Research Center, Guilan University of Medical Sciences, Rasht, Iran. ⁴¹⁴Department of Pediatrics, Yonsei University, Seoul, South Korea. ⁴¹⁵Research Department, Electronic Medical Records for the Developing World, York, UK. ⁴¹⁶Transdisciplinary Centre for Qualitative Methods, Manipal Academy of Higher Education, Manipal, India. ⁴¹⁷Nevada Division of Public and Behavioral Health, Carson City, NV, USA. ⁴¹⁸Department of Pharmacology and Therapeutics, Dhaka Medical College, Dhaka, Bangladesh. ⁴¹⁹Department of Pharmacology, Bangladesh Industrial Gases Limited, Tangail, Bangladesh. ⁴²⁰Department of Epidemiology and Biostatistics, Tehran University of Medical Sciences, Tehran, Iran. ⁴²¹Department of Computer Engineering, Islamic Azad University, Tehran, Iran. ⁴²²Computer Science Department, University of Human Development, Sulaymaniyah, Iraq. ⁴²³Department of General Surgery, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. ⁴²⁴Department of Internal Medicine, Bucharest Emergency Hospital, Bucharest, Romania. ⁴²⁵Faculty of Dentistry, Department of Legal Medicine and Bioethics, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. ⁴²⁶Clinical Legal Medicine Department, National Institute of Legal Medicine, Bucharest, Romania. ⁴²⁷Division of Information and Computing Technology, Hamad Bin Khalifa University, Doha, Qatar. ⁴²⁸Medicine School of Tunis, Baab Saadoun, Tunisia. ⁴²⁹Department of Epidemiology and Health Statistics, Central South University, Changsha, China. ⁴³⁰School of Public Health, University of Sydney, Sydney, New South Wales, Australia. ⁴³¹Maternal and Child Health Division, International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh. ⁴³²Department of Public Health and Community Medicine, Shaikh Khalifa Bin Zayed Al-Nahyan Medical College at Shaikh Zayed Medical Complex, Lahore, Pakistan. ⁴³³Department of Occupational Safety and Health, China Medical University, Taichung, Taiwan. ⁴³⁴Department of Epidemiology, University of Kragujevac, Kragujevac, Serbia. ⁴³⁵Department of Public Health, Lorestan University of Medical Sciences, Khorramabad, Iran. ⁴³⁶Department of Family Medicine, Bangalore Baptist Hospital, Bangalore, India. ⁴³⁷Global Health and Development Department, Taipei Medical University, Taipei City, Taiwan. ⁴³⁸Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁴³⁹Institute for Physical Activity and Nutrition, Deakin University, Burwood, Victoria, Australia. ⁴⁴⁰Sydney Medical School, University of Sydney, Sydney, New South Wales, Australia. ⁴⁴¹School of Health Systems and Public Health, University of Pretoria, Hatfield, South Africa. ⁴⁴²Cochrane Center, South African Medical Research Council, Parow Valley, South Africa. ⁴⁴³Health Systems and Public Health, Stellenbosch University, Cape Town, South Africa. ⁴⁴⁴Department of Epidemiology, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁴⁴⁵Department of Environmental Health Engineering, Guilan University of Medical Sciences, Rasht, Iran. ⁴⁴⁶Medical Research Council South Africa, Cape Town, South Africa. ⁴⁴⁷Centre for Evidence Based Health Care, Stellenbosch University, Cape Town, South Africa. ⁴⁴⁸Department of Immunology, Tabriz University of Medical Sciences, Tabriz, Iran. ⁴⁴⁹Department of Psychosis, Babol Noshirvani University of Technology, Babol, Iran. ⁴⁵⁰Department of Immunology, Isfahan University of Medical Sciences, Isfahan, Iran. ⁴⁵¹Department for Health Care and Public Health, Sechenov First Moscow State Medical University, Moscow, Russia. ⁴⁵²Department of Psychiatry, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁴⁵³Social Development & Health Promotion Research Center, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁴⁵⁴Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁴⁵⁵Institute of Medicine, University of Colombo, Colombo, Sri Lanka. ⁴⁵⁶University of Colombo, Colombo, Sri Lanka. ⁴⁵⁷Achutha Menon Centre for Health Science Studies, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, India. ⁴⁵⁸Department of Pediatrics & Child Health, Aga Khan University, Karachi, Pakistan. ⁴⁵⁹Autism Spectrum Disorders Research Center, Hamadan University of Medical Sciences, Hamadan, Iran. ⁴⁶⁰Department of Community Medicine, Banaras Hindu University, Varanasi, India. ⁴⁶¹Manipal Academy of Higher Education, Manipal, India. ⁴⁶²The George Institute for Global Health, University of New South Wales, New Delhi, India. ⁴⁶³Environmental Research Center, Duke Kunshan University, Kunshan, China. ⁴⁶⁴Nicholas School of the Environment, Duke University, Durham, NC, USA.

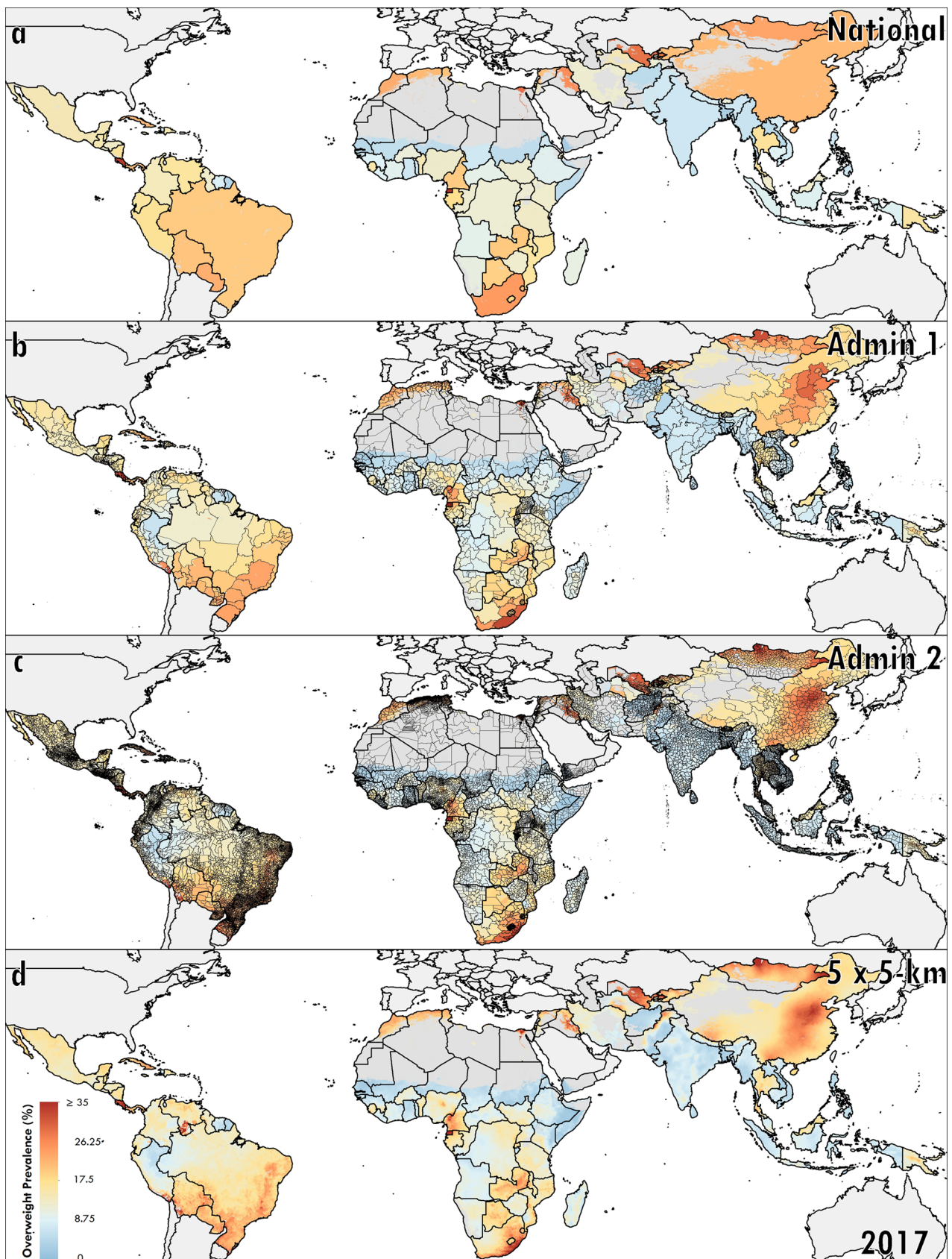
⁴⁶⁵Department of Earth Observation Science, University of Twente, Enschede, the Netherlands. ⁴⁶⁶Department of Ophthalmology, Heidelberg University, Mannheim, Germany. ⁴⁶⁷Beijing Ophthalmology & Visual Science Key Laboratory, Beijing Tongren Hospital, Beijing, China. ⁴⁶⁸Department of Community Medicine, Manipal Academy of Higher Education, Mangalore, India. ⁴⁶⁹Department of Family Medicine and Public Health, University of Opole, Opole, Poland. ⁴⁷⁰School of Health Sciences, Savitribai Phule Pune University, Pune, India. ⁴⁷¹Institute of Family Medicine and Public Health, University of Tartu, Tartu, Estonia. ⁴⁷²Minimally Invasive Surgery Research Center, Iran University of Medical Sciences, Tehran, Iran. ⁴⁷³School of Public Health, University College Cork, Cork, UK. ⁴⁷⁴Infectious Diseases Research Center, Golestan University of Medical Sciences, Gorgan, Iran. ⁴⁷⁵Department of Medical Informatics, Tabriz University of Medical Sciences, Tabriz, Iran. ⁴⁷⁶Health Services Management Department, School of Health Qazvin University of Medical Sciences Qazvin, Qazvin, Iran. ⁴⁷⁷Community Medicine Department, Rafsanjan University of Medical Sciences, Rafsanjan, Iran. ⁴⁷⁸Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Jodhpur, India. ⁴⁷⁹All India Institute of Medical Sciences, New Delhi, India. ⁴⁸⁰Department of Epidemiology, Hamadan University of Medical Sciences, Hamadan, Iran. ⁴⁸¹Institute for Epidemiology and Social Medicine, University of Münster, Münster, Germany. ⁴⁸²Research and Development, Australian Red Cross Blood Service, Sydney, New South Wales, Australia. ⁴⁸³Hematology-Oncology and Stem Cell Transplantation Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁴⁸⁴Pars Advanced and Minimally Invasive Medical Manners Research Center, Iran University of Medical Sciences, Tehran, Iran. ⁴⁸⁵Clinical Pharmacy Unit, Mekelle University, Mekelle, Ethiopia. ⁴⁸⁶Department of Anesthesiology & Pain Medicine, University of Washington, Seattle, WA, USA. ⁴⁸⁷Department of Public Health, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁴⁸⁸Non-Communicable Diseases Research Unit, Medical Research Council South Africa, Cape Town, South Africa. ⁴⁸⁹Department of Medicine, University of Cape Town, Cape Town, South Africa. ⁴⁹⁰Department of Public Health, Debre Markos University, Debre Markos, Ethiopia. ⁴⁹¹Department of Public Health, Jordan University of Science and Technology, Irbid, Jordan. ⁴⁹²Social Determinants of Health Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. ⁴⁹³Department of Physiology, Lorestan University of Medical Sciences, Khorramabad, Iran. ⁴⁹⁴School of Food and Agricultural Sciences, University of Management and Technology, Lahore, Pakistan. ⁴⁹⁵Department of Physiology, Baku State University, Baku, Azerbaijan. ⁴⁹⁶School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Queensland, Australia. ⁴⁹⁷Epidemiology and Biostatistics Department, Health Services Academy, Islamabad, Pakistan. ⁴⁹⁸Department of Population Sciences, Jatiya Kabi Kazi Nazrul Islam University, Mymensingh, Bangladesh. ⁴⁹⁹Department of Public Health, University of Newcastle, Newcastle, New South Wales, Australia. ⁵⁰⁰Department of Hospital Medicine, Miriam Hospital, Brown University, Providence, RI, USA. ⁵⁰¹Department of Internal Medicine, John H. Stroger, Jr. Hospital of Cook County, Chicago, IL, USA. ⁵⁰²Department of Internal Medicine, Dow University of Health Sciences, Karachi, Pakistan. ⁵⁰³Faculty of Health and Wellbeing, Sheffield Hallam University, Sheffield, UK. ⁵⁰⁴College of Arts and Sciences, Ohio University, Zanesville, OH, USA. ⁵⁰⁵Internal Medicine and Gastroenterology Department, National Hepatology and Tropical Research Institute, Cairo, Egypt. ⁵⁰⁶Department of Medical Parasitology, Cairo University, Cairo, Egypt. ⁵⁰⁷Division of Evidence Synthesis, Datta Meghe Institute of Medical Sciences, Wardha, India. ⁵⁰⁸Cancer Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁵⁰⁹Academy of Medical Science, Tehran, Iran. ⁵¹⁰Department of Public Health, Mazandaran University of Medical Sciences, Sari, Iran. ⁵¹¹Department of Biostatistics, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁵¹²Department of Neurosurgery, Iran University of Medical Sciences, Tehran, Iran. ⁵¹³Oxford University Global Surgery Group, University of Oxford, Oxford, UK. ⁵¹⁴Clinical Epidemiology Unit, Lund University, Lund, Sweden. ⁵¹⁵Research and Data Solutions, Synotech Consultant, Nairobi, Kenya. ⁵¹⁶School of Medicine, Xiamen University Malaysia, Sepang, Malaysia. ⁵¹⁷Department of Nutrition, Simmons University, Boston, MA, USA. ⁵¹⁸School of Health Sciences, Kristiania University College, Oslo, Norway. ⁵¹⁹Department of Nursing and Health Promotion, Oslo Metropolitan University, Oslo, Norway. ⁵²⁰Department of Public Health, Ambo University, Ambo, Ethiopia. ⁵²¹Neurophysiology Research Center, Hamadan University of Medical Sciences, Hamadan, Iran. ⁵²²Brain Engineering Research Center, Institute for Research in Fundamental Sciences, Tehran, Iran. ⁵²³Department of Public Health Dentistry, Deemed University, Karad, India. ⁵²⁴Department of Environmental Health Engineering, Arak University of Medical Sciences, Arak, Iran. ⁵²⁵Department of Internal and Pulmonary Medicine, Sheri Kashmir Institute of Medical Sciences, Srinagar, India. ⁵²⁶CIBERSAM, San Juan de Dios Sanitary Park, Sant Boi de Llobregat, Spain. ⁵²⁷Department of Zoology, University of Oxford, Oxford, UK. ⁵²⁸Harvard Medical School, Harvard University, Boston, MA, USA. ⁵²⁹Department of Anthropology, Panjab University, Chandigarh, India. ⁵³⁰Department of Family and Community Health, University of Health and Allied Sciences, Ho, Ghana. ⁵³¹Department of Psychology and Health Promotion, University of KwaZulu-Natal, Durban, South Africa. ⁵³²Department of Psychiatry, University of Nairobi, Nairobi, Kenya. ⁵³³Division of Psychology and Language Sciences, University College London, London, UK. ⁵³⁴Department of Medicine Brigham and Women's Hospital, Harvard University, Boston, MA, USA. ⁵³⁵Department of Pathology and Molecular Medicine, McMaster University, Hamilton, Ontario, Canada. ⁵³⁶Institute of Occupational and Environmental Medicine, University of Birmingham, Birmingham, UK. ⁵³⁷Health and Nutrition Section, United Nations Children's Fund (UNICEF), Accra, Ghana. ⁵³⁸Clinical Medicine and Community Health, University of Milan, Milano, Italy. ⁵³⁹National Institute for Health Research (NIHR), Oxford Biomedical Research Centre, Oxford, UK. ⁵⁴⁰Department of Internal Medicine, Post Graduate Institute of Medical Education and Research, Chandigarh, India. ⁵⁴¹Public Health Foundation of India, Gurugram, India. ⁵⁴²Department of Community and Family Medicine, University of Baghdad, Baghdad, Iraq. ⁵⁴³School of Medicine, Deakin University, Geelong, Victoria, Australia. ⁵⁴⁴Health Promotion and Chronic Disease Prevention Branch, Public Health Agency of Canada, Ottawa, Ontario, Canada. ⁵⁴⁵HelpMeSee, New York, NY, USA. ⁵⁴⁶International Relations, Mexican Institute of Ophthalmology, Queretaro, Mexico. ⁵⁴⁷Department of Otorhinolaryngology (ENT) & Head and Neck Surgery, Father Muller Medical College, Mangalore, India. ⁵⁴⁸Department of Information and Internet Technologies, I.M. Sechenov First Moscow State Medical University, Moscow, Russia. ⁵⁴⁹Federal Research Institute for Health Organization and Informatics of the Ministry of Health (FRIHOI), Moscow, Russia. ⁵⁵⁰School of Nursing, Hong Kong Polytechnic University, Hong Kong, China. ⁵⁵¹School of Pharmacy, Monash University, Bandar Sunway, Malaysia. ⁵⁵²School of Pharmacy, Taylor's University Lakeside Campus, Subang Jaya, Malaysia. ⁵⁵³Oxford University Clinical Research Unit, Wellcome Trust Asia Programme, Hanoi, Vietnam. ⁵⁵⁴Department of Medicine, University of Malaya, Kuala Lumpur, Malaysia. ⁵⁵⁵Department of Medicine and Therapeutics, The Chinese University of Hong Kong, Hong Kong, China. ⁵⁵⁶School of Public Health, University of Haifa, Haifa, Israel. ⁵⁵⁷Centre for Chronic Disease Control, Beijing, China. ⁵⁵⁸Department of Epidemiology, Brown University, Providence, RI, USA. ⁵⁵⁹Department of Paediatrics, All India Institute of Medical Sciences, New Delhi, India. ⁵⁶⁰Vector Biology, Liverpool School of Tropical Medicine, Liverpool, UK. ⁵⁶¹Department of Nutrition, University of the Philippines Manila, Manila, Philippines. ⁵⁶²Alliance for Improving Health Outcomes, Inc., Quezon City, Philippines. ⁵⁶³Institute of Nutrition, Friedrich Schiller University Jena, Jena, Germany. ⁵⁶⁴Competence Cluster for Nutrition and Cardiovascular Health (nutriCARD), Jena, Germany. ⁵⁶⁵Ariadne Labs, Harvard University, Boston, MA, USA. ⁵⁶⁶Development and Communication Studies, University of the Philippines Los Baños, Laguna, Philippines. ⁵⁶⁷Pathology Department, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia. ⁵⁶⁸Radiology Department, Mansoura University Hospital, Mansoura, Egypt. ⁵⁶⁹Ophthalmology Department, Aswan Faculty of Medicine, Aswan, Egypt. ⁵⁷⁰Department of Internal Medicine, Grant Medical College & Sir J.J. Group of Hospitals, Mumbai, India. ⁵⁷¹Institute of Medicine, Tribhuvan University, Kathmandu, Nepal. ⁵⁷²Health Education and Research Department, SDM College of Medical Sciences & Hospital, Dharwad, India. ⁵⁷³Health University, Rajiv Gandhi University of Health Sciences, Bangalore, India. ⁵⁷⁴Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran. ⁵⁷⁵Clinical Research Development Center, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁵⁷⁶Department of Maternal and Child Nursing and Public Health, Federal University of Minas Gerais, Belo Horizonte, Brazil. ⁵⁷⁷Plastic Surgery Department, Iran University of Medical Sciences, Tehran, Iran. ⁵⁷⁸Joint Centre for Bioethics, University of Toronto, Toronto, Ontario, Canada. ⁵⁷⁹Ophthalmology Department, Iran University of Medical Sciences, Tehran, Iran. ⁵⁸⁰Ophthalmology Department, University of Manitoba, Winnipeg, Manitoba, Canada. ⁵⁸¹School of Science and Health, Western Sydney University, Sydney, New South Wales, Australia. ⁵⁸²Substance Abuse Prevention Research Center, Kermanshah University of

Medical Sciences, Kermanshah, Iran. ⁵⁸³Department of Population Studies, University of Zambia, Lusaka, Zambia. ⁵⁸⁴Research Department, Grupo de Investigación Fundovida - Fundovida IPS, Cartagena, Colombia. ⁵⁸⁵Grupo de Investigación en Economía de la Salud, University of Cartagena, Cartagena, Colombia. ⁵⁸⁶Campus Caucaia, Federal Institute of Education, Science and Technology of Ceará, Caucaia, Brazil. ⁵⁸⁷Public Health Department, Botho University-Botswana, Gaborone, Botswana. ⁵⁸⁸Division of Plastic Surgery, University of Washington, Seattle, WA, USA. ⁵⁸⁹Research Department, The George Institute for Global Health, New Delhi, India. ⁵⁹⁰School of Medicine, University of New South Wales, Sydney, New South Wales, Australia. ⁵⁹¹ICF International, DHS Program, Rockville, MD, USA. ⁵⁹²Department of Twin Research and Genetic Epidemiology, King's College London, London, UK. ⁵⁹³Neurology Department, Janakpuri Super Specialty Hospital Society, New Delhi, India. ⁵⁹⁴Neurology Department, Govind Ballabh Institute of Medical Education and Research, New Delhi, India. ⁵⁹⁵Pharmacology and Toxicology, Hamadan University of Medical Sciences, Hamadan, Iran. ⁵⁹⁶Department of Epidemiology and Biostatistics, University of California San Francisco, San Francisco, CA, USA. ⁵⁹⁷Public Health and Mortality, International Institute for Population Sciences, Mumbai, India. ⁵⁹⁸Department of Nutrition, University of Oslo, Oslo, Norway. ⁵⁹⁹Mekelle University, Mekelle, Ethiopia. ⁶⁰⁰Peru Country Office, United Nations Population Fund (UNFPA), Lima, Peru. ⁶⁰¹Forensic Medicine Division, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia. ⁶⁰²Department of Midwifery, Adigrat University, Adigrat, Ethiopia. ⁶⁰³Center for Translation Research and Implementation Science, National Institutes of Health, Bethesda, MD, USA. ⁶⁰⁴Breast Surgery Unit, Helsinki University Hospital, Helsinki, Finland. ⁶⁰⁵University of Helsinki, Helsinki, Finland. ⁶⁰⁶Department of Propedeutics of Internal Diseases & Arterial Hypertension, Pomeranian Medical University, Szczecin, Poland. ⁶⁰⁷Health Policy and Management, Centre for Regional Policy Research and Cooperation 'Studiorum', Skopje, Macedonia. ⁶⁰⁸Pacific Institute for Research & Evaluation, Calverton, MD, USA. ⁶⁰⁹Department of Health Research Methods, Evidence and Impact, McMaster University, Hamilton, Ontario, Canada. ⁶¹⁰Global Institute of Public Health (GIPH), Ananthapuri Hospitals and Research Centre, Trivandrum, India. ⁶¹¹Department of Clinical Biochemistry, Babol University of Medical Sciences, Babol, Iran. ⁶¹²Golestan University of Medical Sciences, Gorgan, Iran. ⁶¹³Department of Environmental Health, Sabzevar University of Medical Sciences, Sabzevar, Iran. ⁶¹⁴Foodborne and Waterborne Diseases Research Center, Research Institute for Gastroenterology and Liver Diseases, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁶¹⁵Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan. ⁶¹⁶Department of Atherosclerosis and Coronary Heart Disease, National Center of Cardiology and Internal Disease, Bishkek, Kyrgyzstan. ⁶¹⁷Research Center for Biochemistry and Nutrition in Metabolic Diseases, Kashan University of Medical Sciences, Kashan, Iran. ⁶¹⁸Department of Rehabilitation and Sports Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁶¹⁹Deputy of Social Health, Iran University of Medical Sciences, Tehran, Iran. ⁶²⁰Health Equity Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁶²¹Social Determinants of Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran. ⁶²²Research Center, Salahaddin University, Erbil, Iraq. ⁶²³Internal Medicine Department, King Saud University, Riyadh, Saudi Arabia. ⁶²⁴Department of Food Technology, Salahaddin University, Erbil, Iraq. ⁶²⁵Department of Medicine, Karolinska Institutet, Stockholm, Sweden. ⁶²⁶Department of Information Technology, University of Human Development, Sulaymaniyah, Iraq. ⁶²⁷Department of Biostatistics, Hamadan University of Medical Sciences, Hamadan, Iran. ⁶²⁸Department of Epidemiology and Biostatistics, Shahrekord University of Medical Sciences, Shahrekord, Iran. ⁶²⁹Department of Immunology, Babol University of Medical Sciences, Babol, Iran. ⁶³⁰Clinical Biochemistry, Tarbiat Modares University, Tehran, Iran. ⁶³¹Department of Nursing, Shahroud University of Medical Sciences, Shahroud, Iran. ⁶³²Department of Biomolecular Sciences, University of Mississippi, Oxford, MS, USA. ⁶³³Department of Pharmacy, Mizan-Tepi University, Mizan, Ethiopia. ⁶³⁴Health Systems and Policy Research Unit, Ahmadu Bello University, Zaria, Nigeria. ⁶³⁵School of Pharmacy, Haramaya University, Harar, Ethiopia. ⁶³⁶Iran National Institute of Health Research, Tehran University of Medical Sciences, Tehran, Iran. ⁶³⁷Community Nutrition, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁶³⁸Health Systems Research Center, National Health Research Institutes, Cuernavaca, Mexico. ⁶³⁹Department of Public Health Sciences, University of Miami, Miami, FL, USA. ⁶⁴⁰Department of Public Health Medicine, University of KwaZulu-Natal, Durban, South Africa. ⁶⁴¹Department of Molecular Medicine, Birjand University of Medical Sciences, Birjand, Iran. ⁶⁴²Department of Epidemiology and Biostatistics, Kurdistan University of Medical Sciences, Sanandaj, Iran. ⁶⁴³Department of Epidemiology, Iran University of Medical Sciences, Tehran, Iran. ⁶⁴⁴Department of Economics and Management Sciences for Health, Tehran University of Medical Sciences, Tehran, Iran. ⁶⁴⁵Department of Mathematical Sciences, University of Bath, Bath, UK. ⁶⁴⁶Department of Surgery, University of Washington, Seattle, WA, USA. ⁶⁴⁷Department of Clinical Biochemistry, Tarbiat Modares University, Tehran, Iran. ⁶⁴⁸Food Science, University of Campinas, Campinas, Brazil. ⁶⁴⁹Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA. ⁶⁵⁰Federal Institute for Population Research, Wiesbaden, Germany. ⁶⁵¹Center for Population and Health, Wiesbaden, Germany. ⁶⁵²Indian Institute of Public Health - Hyderabad, Public Health Foundation of India, Hyderabad, India. ⁶⁵³School of Medical Sciences, Science University of Malaysia, Kubang Kerian, Malaysia. ⁶⁵⁴Department of Pediatric Medicine, Nishtar Medical University, Multan, Pakistan. ⁶⁵⁵Department of Pediatrics & Pediatric Pulmonology, Institute of Mother & Child Care, Multan, Pakistan. ⁶⁵⁶Department of Microbiology and Immunology, Mekelle University, Mekelle, Ethiopia. ⁶⁵⁷Department of Urology, Tehran University of Medical Sciences, Tehran, Iran. ⁶⁵⁸Department of Medicine, Icahn School of Medicine at Mount Sinai, New York, NY, USA. ⁶⁵⁹Research and Analytics, Initiative for Financing Health and Human Development, Chennai, India. ⁶⁶⁰Research and Analytics, Bioinsilico Technologies, Chennai, India. ⁶⁶¹Initiative for Non Communicable Diseases, International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh. ⁶⁶²Comprehensive Cancer Center, University of Alabama at Birmingham, Birmingham, AL, USA. ⁶⁶³Department of Epidemiology & Biostatistics, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁶⁶⁴Department of Disease, Epidemics, and Pandemics Control, Ministry of Public Health, Yaoundé, Cameroon. ⁶⁶⁵Department of Public Health, University of Yaoundé I, Yaoundé, Cameroon. ⁶⁶⁶Hospital of the Federal University of Minas Gerais, Federal University of Minas Gerais, Belo Horizonte, Brazil. ⁶⁶⁷Department of Pediatrics, Arak University of Medical Sciences, Arak, Iran. ⁶⁶⁸Iranian Ministry of Health and Medical Education, Tehran, Iran. ⁶⁶⁹General Surgery, Emergency Hospital of Bucharest, Bucharest, Romania. ⁶⁷⁰Anatomy and Embryology, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. ⁶⁷¹Cardiology, Cardio-Aid, Bucharest, Romania. ⁶⁷²Department of Biological Sciences, University of Embu, Embu, Kenya. ⁶⁷³Institute for Global Health Innovations, Duy Tan University, Hanoi, Vietnam. ⁶⁷⁴Institute of Mental Health Research, University of Ottawa, Ottawa, Ontario, Canada. ⁶⁷⁵Department of Clinical Epidemiology, Institute for Clinical Evaluative Sciences, Ottawa, Ontario, Canada. ⁶⁷⁶Department of Pharmacology of Tehran University of Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁶⁷⁷Heidelberg University Hospital, Heidelberg, Germany. ⁶⁷⁸Public Health Department, Universitas Negeri Semarang, Kota Semarang, Indonesia. ⁶⁷⁹Graduate Institute of Biomedical Informatics, Taipei Medical University, Taipei City, Taiwan. ⁶⁸⁰School of Public Health and Family Medicine, University of Cape Town, Cape Town, South Africa. ⁶⁸¹Department of Neurobiology, Care Sciences and Society (NVS), H1, Division of Family Medicine and Primary Care, Karolinska Institutet, Huddinge, Sweden. ⁶⁸²Administrative and Economic Sciences, University of Bucharest, Bucharest, Romania. ⁶⁸³Centre of Cardiovascular Research and Education in Therapeutics, Monash University, Melbourne, Victoria, Australia. ⁶⁸⁴Independent Consultant, Accra, Ghana. ⁶⁸⁵Department Obstetrics and Gynecology, University of Ibadan, Ibadan, Nigeria. ⁶⁸⁶Department of Preventive Medicine, Kyung Hee University, Dongdaemun-gu, South Korea. ⁶⁸⁷HAST, Human Sciences Research Council, Durban, South Africa. ⁶⁸⁸School of Public Health, University of Namibia, Osakhaty, Namibia. ⁶⁸⁹Department of Medical Genetics, School of Advanced Technologies in Medicine, Golestan University of Medical Sciences, Gorgan, Iran. ⁶⁹⁰Department of Psychiatry and Behavioural Neurosciences, McMaster University, Hamilton, Ontario, Canada. ⁶⁹¹Department of Psychiatry, University of Lagos, Lagos, Nigeria. ⁶⁹²Centre for Healthy Start Initiative, Lagos, Nigeria. ⁶⁹³Centre for Healthy Start Initiative, Phonics Hearing Centre, Lagos, Nigeria. ⁶⁹⁴Public Health and School of Graduates Studies, Jigjiga University, Jig-Jiga, Ethiopia. ⁶⁹⁵Department of Pharmacology and Therapeutics, University of Nigeria Nsukka, Enugu, Nigeria. ⁶⁹⁶Department of Psychology, University of Ghana, Accra, Ghana. ⁶⁹⁷Graduate School of Public Health, San Diego State University, San Diego, CA, USA. ⁶⁹⁸University of Washington, Seattle, WA, USA. ⁶⁹⁹University of Port Harcourt, Port Harcourt, Nigeria. ⁷⁰⁰School of Medicine, Autonomous University of Madrid, Madrid, Spain. ⁷⁰¹Department of Nephrology and

Hypertension, The Institute for Health Research Foundation Jiménez Díaz University Hospital, Madrid, Spain. ⁷⁰²Department of Environmental Management and Toxicology, University of Benin, Benin City, Nigeria. ⁷⁰³Institute for Advanced Medical Research and Training, University of Ibadan, Ibadan, Nigeria. ⁷⁰⁴Department of Respiratory Medicine, Jagadguru Sri Shivarathreshwara Academy of Health Education and Research, Mysore, India. ⁷⁰⁵Department of Forensic Medicine and Toxicology, Manipal Academy of Higher Education, Mangalore, India. ⁷⁰⁶Department of Medical Mycology and Parasitology, Shiraz University of Medical Sciences, Shiraz, Iran. ⁷⁰⁷Center for Health Outcomes & Evaluation, Bucharest, Romania. ⁷⁰⁸Augenpraxis Jonas, Heidelberg University, Heidelberg, Germany. ⁷⁰⁹Internal Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA, USA. ⁷¹⁰Research and Evaluation, Population Council, New Delhi, India. ⁷¹¹Indian Institute of Health Management Research University, Jaipur, India. ⁷¹²Department of Pediatrics, RD Gardi Medical College, Ujjain, India. ⁷¹³Public Health Sciences, Karolinska Institutet, Stockholm, Sweden. ⁷¹⁴Research & Publication Cell, Kalinga Institute of Medical Sciences, Bhubaneswar, Bhubaneswar, India. ⁷¹⁵Regional Medical Research Centre, Indian Council of Medical Research, Bhubaneswar, India. ⁷¹⁶Department of Population Studies, International Institute for Population Sciences, Mumbai, India. ⁷¹⁷International Institute of Health Management Research, New Delhi, India. ⁷¹⁸Department of Paediatrics, University of Melbourne, Melbourne, Victoria, Australia. ⁷¹⁹Population Health, Murdoch Childrens Research Institute, Melbourne, Victoria, Australia. ⁷²⁰Wolaita Sodo University, Sodo, Ethiopia. ⁷²¹Department of Physiology, Iran University of Medical Sciences, Tehran, Iran. ⁷²²Center for Research and Innovation, Ateneo De Manila University, Pasig City, Philippines. ⁷²³Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Bergamo, Italy. ⁷²⁴School of Medicine, University of Virginia, Charlottesville, VA, USA. ⁷²⁵HIV and Mental Health Department, Integrated Development Foundation Nepal, Kathmandu, Nepal. ⁷²⁶University Medical Center Groningen, University of Groningen, Groningen, the Netherlands. ⁷²⁷Faculty of Economics and Business, University of Groningen, Groningen, the Netherlands. ⁷²⁸Department of Public Health, Maragheh University of Medical Sciences, Maragheh, Iran. ⁷²⁹Department of Nutrition and Food Sciences, Maragheh University of Medical Sciences, Maragheh, Iran. ⁷³⁰School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada. ⁷³¹Paramedic Department, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁷³²Digestive Diseases Research Institute, Tehran University of Medical Sciences, Tehran, Iran. ⁷³³Fundación Valle del Lili, Cali, Colombia. ⁷³⁴Infectious Diseases, National Institute of Infectious Diseases, Bucuresti, Romania. ⁷³⁵Department of Infectious Diseases, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. ⁷³⁶Health Sciences Department, Muhammadiyah University of Surakarta, Sukoharjo, Indonesia. ⁷³⁷Biomedical Engineering Department, Amirkabir University of Technology, Tehran, Iran. ⁷³⁸Department of Chemistry, Sharif University of Technology, Tehran, Iran. ⁷³⁹College of Medicine, University of Central Florida, Orlando, FL, USA. ⁷⁴⁰College of Graduate Health Sciences, A.T. Still University, Mesa, AZ, USA. ⁷⁴¹Department of Immunology, Mazandaran University of Medical Sciences, Sari, Iran. ⁷⁴²Molecular and Cell Biology Research Center, Mazandaran University of Medical Sciences, Sari, Iran. ⁷⁴³Thalassemia and Hemoglobinopathy Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. ⁷⁴⁴Metabolomics and Genomics Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁷⁴⁵Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁷⁴⁶School of Nursing and Healthcare Professions, Federation University, Heidelberg, Victoria, Australia. ⁷⁴⁷National Centre for Farmer Health, Deakin University, Waurn Ponds, Victoria, Australia. ⁷⁴⁸Department of Clinical Pediatrics, Sweidi Hospital, Riyadh, Saudi Arabia. ⁷⁴⁹Department of Pediatrics, North-West University, Peshawar, Pakistan. ⁷⁵⁰Society for Health and Demographic Surveillance, Suri, India. ⁷⁵¹Department of Economics, University of Göttingen, Göttingen, Germany. ⁷⁵²Birjand University of Medical Sciences, Birjand, Iran. ⁷⁵³Department of Pharmacology, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁷⁵⁴University Institute of Public Health, University of Lahore, Lahore, Pakistan. ⁷⁵⁵Public Health Department, University of Health Sciences, Lahore, Pakistan. ⁷⁵⁶Policy Research Institute, Kathmandu, Nepal. ⁷⁵⁷Institute for Poverty Alleviation and International Development, Yonsei University, Wonju, South Korea. ⁷⁵⁸Department of Oral Pathology, Srinivas Institute of Dental Sciences, Mangalore, India. ⁷⁵⁹Gonçalo Moniz Institute, Oswaldo Cruz Foundation, Salvador, Brazil. ⁷⁶⁰Institute of Public Health, Federal University of Bahia, Salvador, Brazil. ⁷⁶¹School of Behavioral Sciences and Mental Health, Tehran Institute of Psychiatry, Tehran, Iran. ⁷⁶²Kasturba Medical College, Manipal Academy of Higher Education, Mangalore, India. ⁷⁶³Department of Primary Care and Public Health, Imperial College London, London, UK. ⁷⁶⁴Academic Public Health Department, Public Health England, London, UK. ⁷⁶⁵WHO Collaborating Centre for Public Health Education and Training, Imperial College London, London, UK. ⁷⁶⁶University College London Hospitals, London, UK. ⁷⁶⁷School of Health, Medical and Applied Sciences, Central Queensland University, Sydney, New South Wales, Australia. ⁷⁶⁸Neurology Department, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, India. ⁷⁶⁹School of Social Sciences and Psychology, Western Sydney University, Penrith, New South Wales, Australia. ⁷⁷⁰Translational Health Research Institute, Western Sydney University, Penrith, New South Wales, Australia. ⁷⁷¹Brien Holden Vision Institute, Sydney, New South Wales, Australia. ⁷⁷²Organization for the Prevention of Blindness, Paris, France. ⁷⁷³Network of Immunity in Infection, Malignancy and Autoimmunity (NIIMA), Universal Scientific Education and Research Network (USERN), Tehran, Iran. ⁷⁷⁴Pediatric Infectious Diseases Research Center, Mazandaran University of Medical Sciences, Sari, Iran. ⁷⁷⁵Department of Epidemiology, Birjand University of Medical Sciences, Birjand, Iran. ⁷⁷⁶EPIUnit - Public Health Institute University Porto (ISPUP), University of Porto, Porto, Portugal. ⁷⁷⁷Surgery Department, University of Minnesota, Minneapolis, MN, USA. ⁷⁷⁸Surgery Department, University Teaching Hospital of Kigali, Kigali, Rwanda. ⁷⁷⁹School of Psychology, University of Lincoln, Lincoln, UK. ⁷⁸⁰Department of Epidemiology and Biostatistics, Imperial College London, London, UK. ⁷⁸¹Department of Clinical Research, Federal University of Uberlândia, Uberlândia, Brazil. ⁷⁸²Department of Public Health, Wollega University, Nekemte, Ethiopia. ⁷⁸³Public Health Department, Addis Ababa University, Addis Ababa, Ethiopia. ⁷⁸⁴Golestan Research Center of Gastroenterology and Hepatology, Golestan University of Medical Sciences, Gorgan, Iran. ⁷⁸⁵Infectious Diseases and Tropical Medicine Research Center, Babol University of Medical Sciences, Babol, Iran. ⁷⁸⁶Centro de Investigación Palmira, Agrosavia, Palmira, Colombia. ⁷⁸⁷Department of Ocean Science and Engineering, Southern University of Science and Technology, Shenzhen, China. ⁷⁸⁸Ain Shams University, Cairo, Egypt. ⁷⁸⁹Department of Cardiology, Tehran University of Medical Sciences, Tehran, Iran. ⁷⁹⁰National Institute for Research in Environmental Health, Indian Council of Medical Research, Bhopal, India. ⁷⁹¹Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran. ⁷⁹²Emergency Department, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁷⁹³Department of Health in Disasters and Emergencies, Shahid Beheshti University of Medical Sciences, Tehran, Iran. ⁷⁹⁴Department of Psychiatry, All India Institute of Medical Sciences, New Delhi, India. ⁷⁹⁵Halal Research Center of IRI, FDA, Tehran, Iran. ⁷⁹⁶Neurogenic Inflammation Research Center, Mashhad University of Medical Sciences, Mashhad, Iran. ⁷⁹⁷Nanobiotechnology Center, Soran University, Soran, Iraq. ⁷⁹⁸Department of Anatomical Sciences, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁷⁹⁹Department of Pathology, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia. ⁸⁰⁰Taleghani Hospital, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁸⁰¹Radiology and Nuclear Medicine Department, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁸⁰²Taleghani Hospital, Kermanshah, Iran. ⁸⁰³Urology Department, Cairo University, Cairo, Egypt. ⁸⁰⁴Public Health and Community Medicine, Cairo University, Giza, Egypt. ⁸⁰⁵Drug Applied Research Center, Tabriz University of Medical Sciences, Tabriz, Iran. ⁸⁰⁶Department of Entomology, Ain Shams University, Cairo, Egypt. ⁸⁰⁷Department of Internal Medicine, University of São Paulo, São Paulo, Brazil. ⁸⁰⁸Department of Infectious Diseases and Tropical Medicine, Federal University of Minas Gerais, Belo Horizonte, Brazil. ⁸⁰⁹Department of Community Medicine, PSG Institute of Medical Sciences and Research, Coimbatore, India. ⁸¹⁰PSG-FAIMER, South Asia Regional Institute, Coimbatore, India. ⁸¹¹Health Economics and Financing Research Group, International Centre for Diarrhoeal Disease Research, Bangladesh, Dhaka, Bangladesh. ⁸¹²Faculty of Infectious and Tropical Diseases, London School of Hygiene & Tropical Medicine, London, UK. ⁸¹³Colorectal Research Center, Iran University of Medical Sciences, Tehran, Iran. ⁸¹⁴Surgery Department, Hamad General Hospital, Hamad Medical Corporation, Doha, Qatar. ⁸¹⁵Faculty of Health & Social Sciences, Bournemouth University, Bournemouth, UK. ⁸¹⁶UGC Centre of Advanced Study in Psychology, Utkal University, Bhubaneswar, India. ⁸¹⁷Udyam-Global Association for Sustainable Development, Bhubaneswar, India. ⁸¹⁸Hypertension in Africa Research Team (HART), North-West University, Potchefstroom, South Africa. ⁸¹⁹Unit for Hypertension and

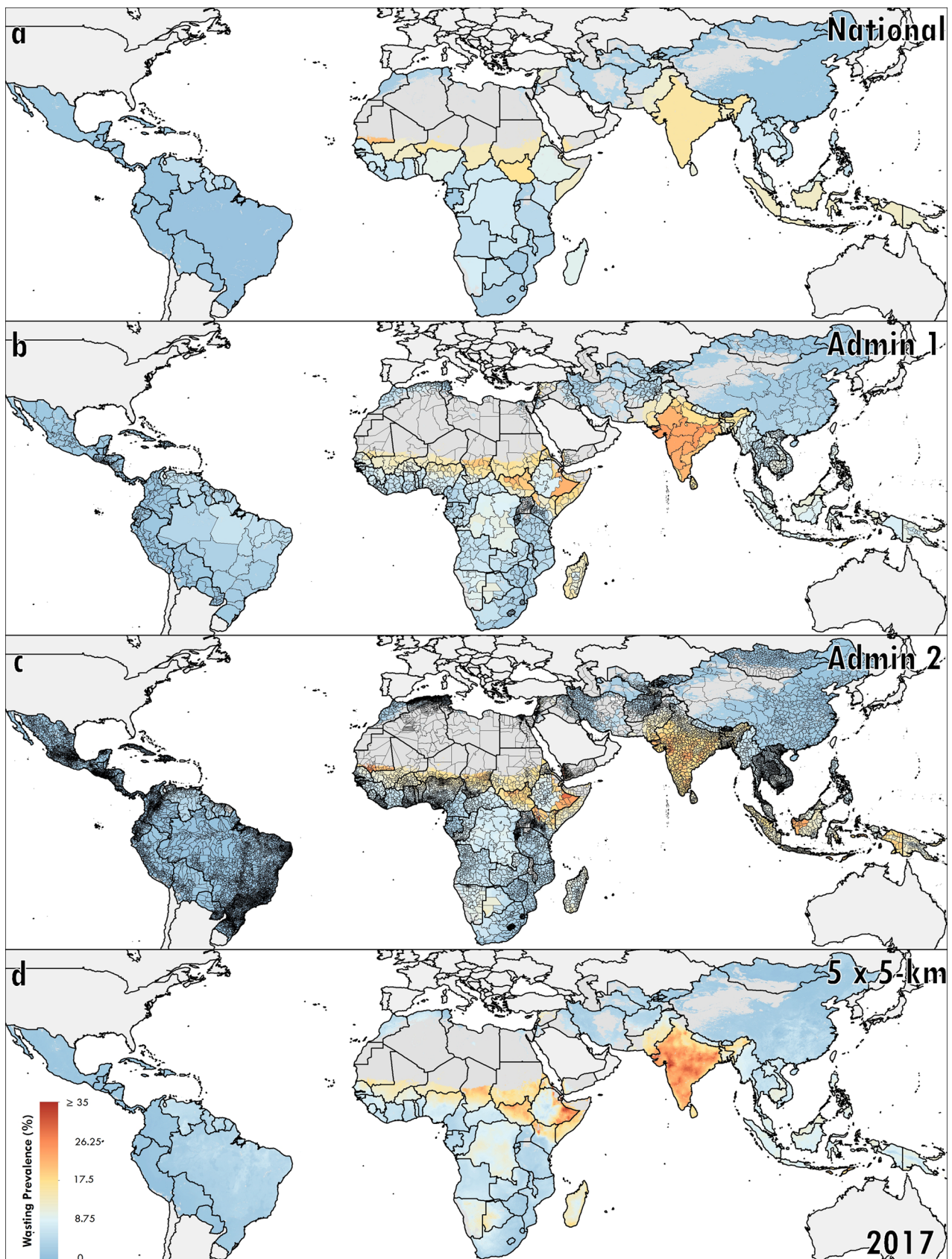
Cardiovascular Disease, South African Medical Research Council, Cape Town, South Africa. ⁸²⁰Department of Psychology, University of Alabama at Birmingham, Birmingham, AL, USA. ⁸²¹Department of Food Science and Nutrition, Jigjiga University, Jigjiga, Ethiopia. ⁸²²Emergency Department, Manian Medical Centre, Erode, India. ⁸²³Microbiology Service, National Institutes of Health, Bethesda, MD, USA. ⁸²⁴Department of Health Promotion and Education, Alborz University of Medical Sciences, Karaj, Iran. ⁸²⁵Health Policy Research Center, Shiraz University of Medical Sciences, Shiraz, Iran. ⁸²⁶Independent Consultant, Karachi, Pakistan. ⁸²⁷Department of Neuropsychiatry, Ain Shams University, Cairo, Egypt. ⁸²⁸School of Medicine, Alborz University of Medical Sciences, Karaj, Iran. ⁸²⁹Medical Laboratory Sciences, Mazandaran University of Medical Sciences, Sari, Iran. ⁸³⁰Chronic Diseases (Home Care) Research Center, Hamadan University of Medical Sciences, Hamadan, Iran. ⁸³¹Department of Development Studies, International Institute for Population Sciences, Mumbai, India. ⁸³²Department of Basic Sciences, Islamic Azad University, Sari, Iran. ⁸³³Department of Laboratory Sciences, Islamic Azad University, Sari, Iran. ⁸³⁴University School of Management and Entrepreneurship, Delhi Technological University, New Delhi, India. ⁸³⁵Department of Health Information Management and Informatics, Iran University of Medical Sciences, Tehran, Iran. ⁸³⁶Institute for Population Health, King's College London, London, UK. ⁸³⁷National Institute of Infectious Diseases, Tokyo, Japan. ⁸³⁸College of Medicine, Yonsei University, Seodaemun-gu, South Korea. ⁸³⁹Division of Cardiology, Emory University, Atlanta, GA, USA. ⁸⁴⁰Finnish Institute of Occupational Health, Helsinki, Finland. ⁸⁴¹Cancer Research Institute, Tehran University of Medical Sciences, Tehran, Iran. ⁸⁴²Cancer Biology Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁸⁴³Institute of Medical Epidemiology, Martin Luther University Halle-Wittenberg, Halle, Germany. ⁸⁴⁴Department of Health Education & Promotion, Kermanshah University of Medical Sciences, Kermanshah, Iran. ⁸⁴⁵School of Health, University of Technology Sydney, Sydney, New South Wales, Australia. ⁸⁴⁶Department of Psychology, Reykjavik University, Reykjavik, Iceland. ⁸⁴⁷Department of Health and Behavior Studies, Columbia University, New York, NY, USA. ⁸⁴⁸Department of Physical Education, Federal University of Santa Catarina, Florianopolis, Brazil. ⁸⁴⁹Department of Law, Economics, Management and Quantitative Methods, University of Sannio, Benevento, Italy. ⁸⁵⁰Menzies Institute for Medical Research, University of Tasmania, Hobart, Tasmania, Australia. ⁸⁵¹Global Patient Outcome and Real World Evidence, Eli Lilly and Company, Indianapolis, IN, USA. ⁸⁵²Department of Humanities and Social Sciences, Indian Institute of Technology, Roorkee, Roorkee, India. ⁸⁵³Department of Pulmonary Medicine, Asthma Bhawan, Jaipur, India. ⁸⁵⁴Department of Medicine, University of Alabama at Birmingham, Birmingham, AL, USA. ⁸⁵⁵Medicine Service, US Department of Veterans Affairs, Birmingham, AL, USA. ⁸⁵⁶Department of Forensic Medicine, Kathmandu University, Dhulikhel, Nepal. ⁸⁵⁷Department of Epidemiology, School of Preventive Oncology, Patna, India. ⁸⁵⁸Department of Epidemiology, Healis Sekhsaria Institute for Public Health, Mumbai, India. ⁸⁵⁹Department of Midwifery, Haramaya University, Harar, Ethiopia. ⁸⁶⁰Department of Physiotherapy and Occupational Therapy, Næstved-Slagelse-Ringsted Hospitals, Slagelse, Denmark. ⁸⁶¹Medical Surgical Nursing Department, Urmia University of Medical Science, Urmia, Iran. ⁸⁶²Emergency Nursing Department, Semnan University of Medical Sciences, Semnan, Iran. ⁸⁶³Midwifery Department, Hamadan University of Medical Sciences, Hamadan, Iran. ⁸⁶⁴Research Center for Environmental Determinants of Health, Academy of Medical Science, Kermanshah, Iran. ⁸⁶⁵Hospital Universitario de la Princesa, Autonomous University of Madrid, Madrid, Spain. ⁸⁶⁶Centro de Investigación Biomédica en Red Enfermedades Respiratorias (CIBERES), Madrid, Spain. ⁸⁶⁷Department of Research Development, Federal Research Institute for Health Organization and Informatics of the Ministry of Health (FRIHOI), Moscow, Russia. ⁸⁶⁸Laboratory of Public Health Indicators Analysis and Health Digitalization, Moscow Institute of Physics and Technology, Moscow, Russia. ⁸⁶⁹Hull York Medical School, University of Hull, Hull City, UK. ⁸⁷⁰Usher Institute of Population Health Sciences and Informatics, University of Edinburgh, Edinburgh, UK. ⁸⁷¹Department of Parasitology and Mycology, Tabriz University of Medical Sciences, Tabriz, Iran. ⁸⁷²Division of Community Medicine, International Medical University, Kuala Lumpur, Malaysia. ⁸⁷³Research Management, Policy, Planning and Coordination, Indian Council of Medical Research, New Delhi, India. ⁸⁷⁴Clinical Department, Nutrition and Dietetics Department, Federal Research Institute of Nutrition, Biotechnology and Food Safety, Moscow, Russia. ⁸⁷⁵Department of Internal Disease, Pirogov Russian National Research Medical University, Moscow, Russia. ⁸⁷⁶Department of Nursing, Muhammadiyah University of Surakarta, Surakarta, Indonesia. ⁸⁷⁷Department of Public Health, China Medical University, Taichung City, Taiwan. ⁸⁷⁸Department of Community Medicine, Ahmadu Bello University, Zaria, Nigeria. ⁸⁷⁹Department of Agriculture and Food Systems, University of Melbourne, Melbourne, Victoria, Australia. ⁸⁸⁰Norwegian Institute of Public Health, Bergen, Norway. ⁸⁸¹Department of Community Health, Muhimbili University of Health and Allied Sciences, Dar Es Salaam, Tanzania. ⁸⁸²Muhimbili University of Health and Allied Sciences, Dar Es Salaam, Tanzania. ⁸⁸³Department of Criminology, Law and Society, University of California Irvine, Irvine, CA, USA. ⁸⁸⁴Department of Medicine, University of Valencia, Valencia, Spain. ⁸⁸⁵Carlos III Health Institute, Biomedical Research Networking Center for Mental Health Network (CiberSAM), Madrid, Spain. ⁸⁸⁶Cancer Control Center, Osaka International Cancer Institute, Osaka, Japan. ⁸⁸⁷Department of Pediatrics, Hawassa University, Hawassa, Ethiopia. ⁸⁸⁸International Vaccine Institute, Seoul, South Korea. ⁸⁸⁹Research Center for Molecular Medicine, Hamadan University of Medical Sciences, Hamadan, Iran. ⁸⁹⁰School of Pharmacy, Mekelle University, Mekelle, Ethiopia. ⁸⁹¹University Institute 'Egas Moniz', Monte da Caparica, Portugal. ⁸⁹²Research Institute for Medicines, University of Lisbon, Lisbon, Portugal. ⁸⁹³Department of Public Health, Adigrat University, Adigrat, Ethiopia. ⁸⁹⁴Pharmacognosy, Mekelle University, Mekelle, Ethiopia. ⁸⁹⁵Department of Pediatrics, King Saud University, Riyadh, Saudi Arabia. ⁸⁹⁶College of Medicine, Alfaisal University, Riyadh, Saudi Arabia. ⁸⁹⁷Department of Anesthesiology, Perioperative, and Pain Medicine, Stanford University, Stanford, CA, USA. ⁸⁹⁸Department of Anesthesiology, King Fahad Medical City, Riyadh, Saudi Arabia. ⁸⁹⁹Department of Endocrinology, Christian Medical College and Hospital (CMC), Vellore, India. ⁹⁰⁰Biology Department, Moscow State University, Moscow, Russia. ⁹⁰¹HIV/STI Surveillance Research Center, and WHO Collaborating Center for HIV Surveillance, Kerman University of Medical Sciences, Kerman, Iran. ⁹⁰²Department of Medicine, University of Calgary, Calgary, Alberta, Canada. ⁹⁰³Department of Pathology and Legal Medicine, University of São Paulo, Ribeirão Preto, Brazil. ⁹⁰⁴Clinical Epidemiology and Public Health Research Unit, Burlo Garofolo Institute for Maternal and Child Health, Trieste, Italy. ⁹⁰⁵Molecular Medicine and Pathology, University of Auckland, Auckland, New Zealand. ⁹⁰⁶Clinical Hematology and Toxicology, Military Medical University, Hanoi, Vietnam. ⁹⁰⁷Department of Neurology, All India Institute of Medical Sciences, Delhi, India. ⁹⁰⁸Department of Pharmacy, Stamford University Bangladesh, Dhaka, Bangladesh. ⁹⁰⁹Gomal Center of Biochemistry and Biotechnology, Gomal University, Dera Ismail Khan, Pakistan. ⁹¹⁰TB Culture Laboratory, Mufti Mehmood Memorial Teaching Hospital Dera Ismail Khan, Dera Ismail Khan, Pakistan. ⁹¹¹Amity Institute of Biotechnology, Amity University Rajasthan, Jaipur, India. ⁹¹²Lifestyle Diseases Research Entity, North-West University, Mmabatho, South Africa. ⁹¹³Division of Health Sciences, University of Warwick, Coventry, UK. ⁹¹⁴Department of Epidemiology and Biostatistics, Umeå University, Umeå, Sweden. ⁹¹⁵Argentine Society of Medicine, Buenos Aires, Argentina. ⁹¹⁶Velez Sarsfield Hospital, Buenos Aires, Argentina. ⁹¹⁷Central Research Institute of Cytology and Genetics, Federal Research Institute for Health Organization and Informatics of the Ministry of Health (FRIHOI), Moscow, Russia. ⁹¹⁸Christian Medical College and Hospital (CMC), Vellore, India. ⁹¹⁹UKK Institute, Tampere, Finland. ⁹²⁰Psychosocial Injuries Research Center, Ilam University of Medical Sciences, Ilam, Iran. ⁹²¹National AIDS Control Organisation, Ministry of Health, New Delhi, India. ⁹²²Raffles Neuroscience Centre, Raffles Hospital, Singapore, Singapore. ⁹²³Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore. ⁹²⁴Community & Family Medicine, All India Institute of Medical Sciences, Bathinda, India. ⁹²⁵Department of Neurology & Stroke Unit, Sant'Anna Hospital, Como, Italy. ⁹²⁶Occupational Health Unit, Sant'Orsola Malpighi Hospital, Bologna, Italy. ⁹²⁷Department of Health Care Administration and Economics, National Research University Higher School of Economics, Moscow, Russia. ⁹²⁸Department of Global Health and Population, Harvard University, Boston, MA, USA. ⁹²⁹School of Medicine, University of Belgrade, Belgrade, Serbia. ⁹³⁰Department of Pediatric Endocrinology, Mother and Child Healthcare Institute of Serbia 'Dr Vukan Cupic', Belgrade, Serbia. ⁹³¹Foundation University Medical College, Foundation University, Islamabad, Pakistan. ⁹³²Department of Epidemiology and Biostatistics, Wuhan University, Wuhan, China. ⁹³³Demographic Change and Ageing Research Area, Federal Institute for Population Research, Wiesbaden, Germany. ⁹³⁴Department of Physical Therapy, Naresuan University, Meung District, Thailand. ⁹³⁵Department of Psychology and Counselling, University of Melbourne, Melbourne, Victoria, Australia. ⁹³⁶Department of Medicine, University of Melbourne, St Albans,

Victoria, Australia. ⁹³⁷Department of Pharmacology and Toxicology, Mekelle University, Mekelle, Ethiopia. ⁹³⁸Department of Pharmacology, Addis Ababa University, Addis Ababa, Ethiopia. ⁹³⁹Department of Nursing, Wollo University, Dessie, Ethiopia. ⁹⁴⁰Department of Orthopaedics, Wenzhou Medical University, Wenzhou, China. ⁹⁴¹School of Medicine, Nanjing University, Nanjing, China. ⁹⁴²Medical Physics Department, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. ⁹⁴³Clinical Cancer Research Center, Milad General Hospital, Tehran, Iran. ⁹⁴⁴Department of Diabetes and Metabolic Diseases, University of Tokyo, Tokyo, Japan. ⁹⁴⁵Department of Preventive Medicine, Northwestern University, Chicago, IL, USA. ⁹⁴⁶School of International Development and Global Studies, University of Ottawa, Ottawa, Ontario, Canada. ⁹⁴⁷Health Services Management Research Center, Kerman University of Medical Sciences, Kerman, Iran. ⁹⁴⁸Department of Health Management, Policy and Economics, Kerman University of Medical Sciences, Kerman, Iran. ⁹⁴⁹Wolkite University, Wolkite, Ethiopia. ⁹⁵⁰Centre for Suicide Research and Prevention, University of Hong Kong, Hong Kong, China. ⁹⁵¹Department of Social Work and Social Administration, University of Hong Kong, Hong Kong, China. ⁹⁵²Department of Psychopharmacology, National Center of Neurology and Psychiatry, Tokyo, Japan. ⁹⁵³Department of Preventive Medicine, Korea University, Seoul, South Korea. ⁹⁵⁴Department of Sociology, Yonsei University, Seoul, South Korea. ⁹⁵⁵Department of Health Policy & Management, Jackson State University, Jackson, MS, USA. ⁹⁵⁶School of Medicine, Tsinghua University, Beijing, China. ⁹⁵⁷Department of Environmental Health, Mazandaran University of Medical Sciences, Sari, Iran. ⁹⁵⁸Environmental Health, Academy of Medical Science, Sari, Iran. ⁹⁵⁹Global Health Institute, Wuhan University, Wuhan, China. ⁹⁶⁰Social Determinants of Health Research Center, Ardabil University of Medical Science, Ardabil, Iran. ⁹⁶¹Department of Medicine, Monash University, Melbourne, Victoria, Australia. ⁹⁶²Student Research Committee, Babol University of Medical Sciences, Babol, Iran. ⁹⁶³Department of Community Medicine, Ardabil University of Medical Science, Ardabil, Iran. ⁹⁶⁴Psychiatry and Psychology Research Center, Tehran University of Medical Sciences, Tehran, Iran. ⁹⁶⁵Maternal and Child Wellbeing Unit, African Population Health Research Centre, Nairobi, Kenya. ⁹⁶⁶Public Health Department, Dilla University, Dilla, Ethiopia. ⁹⁶⁷School of Public Health, Wuhan University of Science and Technology, Wuhan, China. ⁹⁶⁸Hubei Province Key Laboratory of Occupational Hazard Identification and Control, Wuhan University of Science and Technology, Wuhan, China. ⁹⁶⁹Department of Preventive Medicine, Wuhan University, Wuhan, China. ⁹⁷⁰School of Biology and Pharmaceutical Engineering, Wuhan Polytechnic University, Wuhan, China. ✉e-mail: sihay@uw.edu

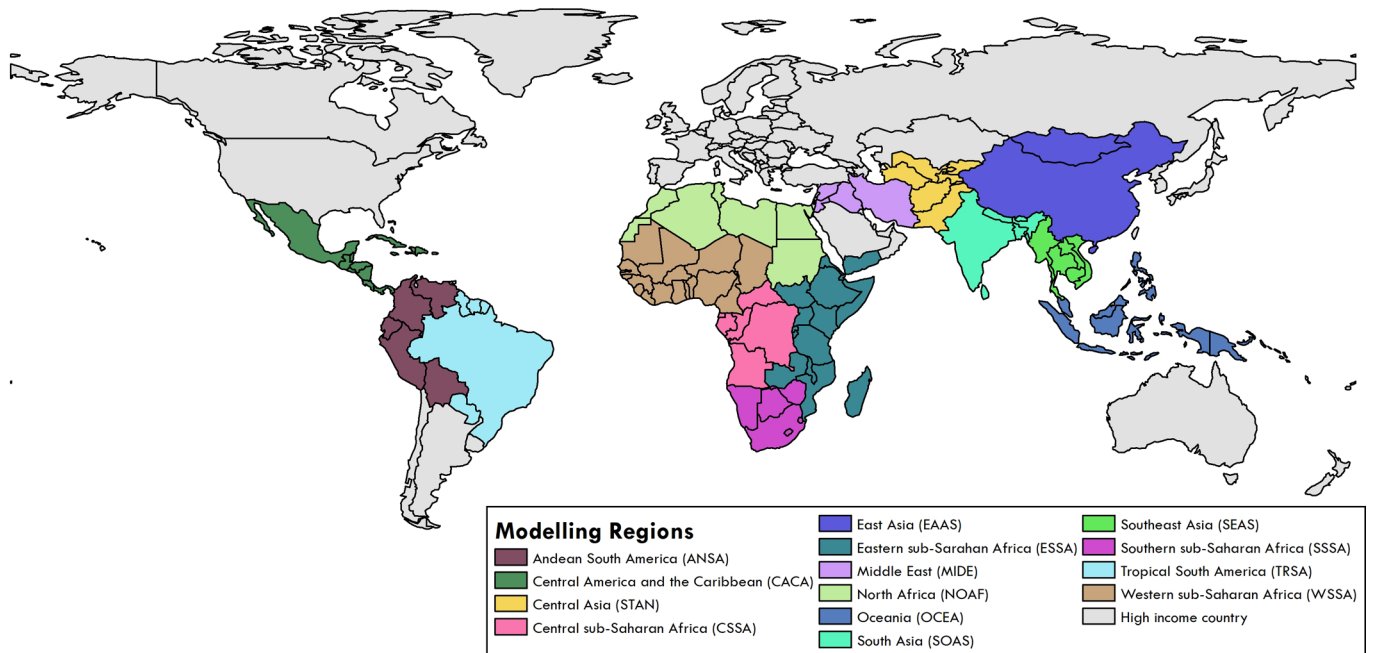


Extended Data Fig. 1 | Prevalence of under-5 childhood overweight in LMICs in 2017 at administrative levels 0, 1, 2, and at 5 × 5-km resolution.

Prevalence of overweight among children under 5 at administrative level 0 (national-level estimates) (**a**), first administrative unit (**b**), second administrative unit (**c**), and at the 5 × 5-km resolution (**d**). Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as "barren or sparsely vegetated" and had fewer than ten people per 1 × 1-km grid cell^{39–45}, or were not included in this analysis. Maps were generated using ArcGIS Desktop 10.6.



Extended Data Fig. 2 | Prevalence of under-5 child wasting in LMICs at administrative levels 0, 1, 2, and at 5 × 5-km resolution in 2017. Prevalence of wasting among children under 5 at administrative level 0 (national-level estimates) (a), first administrative unit (b), second administrative unit (c), and at the 5 × 5-km resolution (d). Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1 × 1-km grid cell^{39–45}, or were not included in this analysis. Maps were generated using ArcGIS Desktop 10.6.



Extended Data Fig. 3 | Modelling regions. Modelling regions⁴⁶ were based on geographic and socio-demographic index (SDI) regions from the Global Burden of Disease⁴⁷, defined as: Andean South America, Central America and the Caribbean, Central sub-Saharan Africa (SSA), East Asia, Eastern SSA, Middle East, North Africa, Oceania, Southeast Asia, South Asia, South SSA, Central Asia, Tropical South America, and Western SSA. Regions in grey (Stage 3) were not included in our models due to high-middle and high SDI. Map was generated using ArcGIS Desktop 10.6.

46. Murray, C. J. et al. GBD 2010: design, definitions and metrics. *Lancet* **380**, 2063–2066 (2012).

Reporting Summary

Nature Research 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 Research policies, see [Authors & Referees](#) 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

- The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement
- A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
- The statistical test(s) used AND whether they are one- or two-sided
Only common tests should be described solely by name; describe more complex techniques in the Methods section.
- A description of all covariates tested
- A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
- 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)
- For null hypothesis testing, the test statistic (e.g. F , t , r) with confidence intervals, effect sizes, degrees of freedom and P value noted
Give P values as exact values whenever suitable.
- For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
- For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
- 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

No primary data collection was carried out for this analysis

Data analysis

This analysis was carried out using R version 3.5.0. The main geostatistical models were fit using R-INLA version 18.07.12. **Additional adjustments were performed using the mgcv package in R (v. 3.5.0).** All code used for these analyses is publicly available online at <http://ghdx.healthdata.org/>. Maps were generated using ArcGIS Desktop 10.6.

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/reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research [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 list of figures that have associated raw data
- A description of any restrictions on data availability

The findings of this study are supported by data available in public online repositories, data that are publicly available upon request from the data provider, and data that are not publicly available due to restrictions by the data provider and which were used under license for the current study. A detailed table of data sources and availability can be found in Supplementary Table 2, and online at ghdx.healthdata.org.

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](https://www.nature.com/documents/nr-reporting-summary-flat.pdf)

Life sciences study design

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

Sample size	Sample size was calculated as the number of unique data source-location pairs with observations of overweight and wasting prevalence. This sample size is reported in the main text under Global and location variation in malnutrition trends, "...using data from 420 household surveys representing more than 3 million children, we map the relative burdens of overweight and wasting among under-5 children in 105 LMICs from 2000 to 2017."
Data exclusions	Reasons for data exclusion were pre-established and are described in supplementary table 5. For a survey to be considered for this analysis, we required information on height, weight, age and sex. Select data sources were excluded from the analysis due to: missing survey weights, missing sex and age variable, incomplete sampling (e.g., only a specific age range), or untrustworthy data (as determined by the survey administrator or by inspection).
Replication	This is an observational study using many years of survey and surveillance data and could be replicated.
Randomization	This analysis is an observational mapping study and there were no experimental groups.
Blinding	Blinding was not relevant to this study, as it was an observational study using survey and surveillance data.

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

Methods

n/a	Involved 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
<input checked="" type="checkbox"/>	<input type="checkbox"/> Animals and other organisms
<input checked="" type="checkbox"/>	<input type="checkbox"/> Human research participants
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clinical data

n/a	Involved 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