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Author/s:

Lozano, R;Fullman, N;Abate, D;Abay, SM;Abbafati, C;Abbasi, N;Abbastabar, H;Abd-Allah, F;Abdela, J;Abdelalim, A;Abdel-Rahman, O;Abdi, A;Abdollahpour, I;Abdulkader, RS;Abebe, ND;Abebe, Z;Abejie, AN;Abera, SP;Abil, OZ;Aboyans, V;Abraha, HN;Abrham, AR;Abu-Raddad, LJ;Abu-Rmeileh, NM;Abyu, GY;Accrombessi, MMK;Acharya, D;Acharya, P;Adamu, AA;Adebayo, OM;Adedeji, IA;Adedoyin, RA;Adekanmbi, V;Adetokunboh, O;Adhena, BM;Adhikari, TR;Adib, MG;Adou, AK;Adsuar, JC;Afarideh, M;Afshari, M;Afshin, A;Agarwal, G;Aghayan, SA;Agius, D;Agrawal, A;Agrawal, S;Ahmadi, A;Ahmadi, M;Ahmadieh, F;Ahmed, MB;Ahmed, S;Akalu, TY;Akanda, AS;Akbari, ME;Akibu, M;Akinyemi, RO;Akinyemiju, T;Akseer, N;Alandab, T;Al-Aly, Z;Alam, K;Alam, T;Abujeer, A;Alebel, A;Alene, KA;Al-Eyadhy, A;Athabib, S;Ali, R;Alijanzadeh, M;Alizadeh-Nayaei, R;Aljunid, SM;Alkerwi, A;Alla, F;Allebeck, P;Allen, CA;Almasi, A;Al-Maskari, F;Al-Mekhlafi, HM;Alonso, J;Al-Raddadi, RM;Alsharif, U;Altirkawi, K;Alvis-Guzman, N;Amare, AT;Amenu, K;Amini, E;Ammar, W;Anber, NH;Anderson, JA;Andrei, CL;Androudi, S;Animut, MD;Anjomshoa, M;Ansari, H;Ansariadi, A;Ansha, MG;Antonio, CAT;Anwari, P;Appiah, LT;Aremu, O;Areri, HA;Arnlov, J;Arora, M;Aryal, KK;Asayesh, H;Asfaw, ET;Asgedom, SW;Asghar, RJ;Assadi, R;Ataro, Z;Atique, S;Atre, SR;Atteraya, MS;Ausloos, M;Avila-Burgos, L;Avokpaho, EFGA;Awasthi, A;Quintanilla, BPA;Ayele, HT;Ayele, Y;Ayer, R;Azarpazhoo, MR;Azzopardi, PS;Azzopardi-Muscat, N;Babalola, TK;Babazadeh, A;Badali, H;Badawi, A;Balakrishnan, K;Bali, AG;Banach, M;Banerjee, A;Banoub, JAM;Banstola, A;Barac, A;Barboza, MA;Barker-Collo, SL;Barnighausen, TW;Barrero, LH;Barthelemy, CM;Bassat, Q;Basu, A;Basu, S;Battista, RJ;Baune, BT;Baynes, HW;Bazargan-Hejazi, S;Bedi, N;Beghi, E;Behzadifar, M;Behzadifar, M;Bejot, Y;Bekele, BB;Belachew, AB;Belay, AG;Belay, SA;Belay, YA;Bell, ML;Bello, AK;Bennett, DA;Bensenor, IM;Benzian, H;Berhane, A;Berhe, AK;Berman, AE;Bernabe, E;Bernstein, RS;Bertolacci, GJ;Beuran, M;Beyranvand, T;Bhala, N;Bhalla, A;Bhansali, A;Bhattarai, S;Bhaumik, S;Bhutta, ZA;Biadgo, B;Biehl, MH;Bijani, A;Rikbov, B;Bililign, N;Bin Sayeed, MS;Birlik, SM;Birungi, C;Bisanzio, D;Biswas, T;Bitew, H;Bizuneh, H;Bjertness, E;Bobasa, EM;Boufous, S;Bourne, R;Bozorgmehr, K;Bragazzi, NL;Brainin, M;Brant, LC;Brauer, M;Brazinova, A;Breitborde, NJK;Briant, PS;Britton, G;Brugha, T;Bukhman, G;Busse, R;Butt, ZA;Cahuana-Hurtado, L;Callender, CSKH;Campos-Nonato, IR;Rincon, JCC;Cano, J;Car, J;Car, M;Cardenas, R;Carrero, JJ;Carter, A;Carvalho, F;Castaneda-Oduela, CA;Rivas, JC;Castro, F;Causey, K;Cavlin, A;Cercy, KM;Cerin, E;Chaiah, Y;Chalek, J;Chang, H-Y;Chang, J-C;Chattopadhyay, A;Chattu, VK;Chaturvedi, P;Chiang, PP-C;Chin, KL;Chisumpa, VH;Chitheer, A;Choi, J-YJ;Chowdhury, R;Christensen, H;Christopher, DJ;Chung, S-C;Cicuttini, FM;Ciobanu, LG;Cirillo, M;Claro, RM;Classen, TKD;Cohen, AJ;Collado-Mateo, D;Cooper, C;Cooper, LT;Cornaby, L;Cortinovis, M;Costa, M;Cousin, E;Cromwell, EA;Crowe, CS;Cunningham, M;Daba, AK;Dadi, AF;Dandona, L;Dandona, R;Hang, AK;Dargan, PI;Daryani, A;Das, SK;Das

Gupta, R;das Neves, J;Dasa, TT;Dash, AP;Davis, AC;Davitoiu, DV;Davletov, K;Dayama, A;de Courten, B;De Leo, D;De Neve, J-W;De Steur, H;Degefa, MG;Degenhardt, L;Degfie, TT;Deiparine, S;Dellavalle, RP;Demoz, GT;Demtsu, B;Denova-Gutierrez, E;Deribe, K;Dervenis, N;Dessie, GA;Dey, S;Dharmaratne, SD;Dhimal, M;Dicker, D;Dinberu, MT;Ding, El;Djalalinia, S;Huyen, PD;Dokova, K;Doku, DT;Douwes-Schultz, D;Driscoll, TR;Duan, L;Dubey, M;Dubljanin, E;Duken, EE;Duncan, BB;Duraes, AR;Ebrahimpour, S;Edvardsson, D;El Bcheraoui, C;Eldrenkamp, E;El-Khatib, Z;Elyazar, IRF;Enayati, A;Endries, AY;Eshrati, B;Eskandanieh, S;Esteghamati, A;Esteghamati, S;Estep, K;Fakhar, M;Fakhim, H;Fanzo, J;Faramarzi, M;Fareed, M;Farhadi, F;Farid, TA;Farinha, CSES;Tarioli, A;Faro, A;Farvid, MS;Farzadfar, F;Farzaei, MH;Tarzam, H;Fazaeli, AA;Fazeli, MS;Feigin, VL;Feigl, AB;Fekadu, W;Feldman, R;Fentahun, N;Fereshtehnejad, S-M;Fernandes, E;Fernandes, JC;Feyissa, GT;Fijabi, DO;Filip, I;Finegold, S;Finger, JD;Tischer, F;Fitzmaurice, C;Flor, LS;Foigt, NA;Foreman, KJ;Frank, TD;Franklin, RC;Fukumoto, T;Fukutaki, K;Fuller, JE;Furst, T;Furtado, JM;Gakidou, E;Gallus, S;Gankpe, FG;Gansevoort, RT;Garcia, AC;Garcia-Basteiro, AL;Garcia-Gordillo, MA;Gardner, WM;Gebre, AK;Gebre, T;Gebregergs, GB;Gebrehiwot, TT;Gebremedhin, AT;Gebremichael, B;Gebremichael, TG;Gelano, TF;Geleijnse, JM;Geramo, YCD;Getachew, S;Gething, PW;Gezae, KE;Ghadami, MR;Ghadimi, R;Ghadiri, K;Ghasemi-Kasman, M;Ghiasvand, H;Ghimire, M;Choshal, AG;Giampaoli, S;Gill, PS;Gill, TK;Giussani, G;Gnedovskaya, EV;Goldberg, EM;Goli, S;Gona, PN;Goodridge, A;Gopalani, SV;Gorman, TM;Goto, A;Coulart, AC;Coulart, BNG;Grada, A;Griswold, MG;Grosso, G;Gugnani, HCC;Guillemin, F;Guimaraes, ALS;Guo, Y;Gupta, PC;Gupta, R;Gupta, R;Gupta, T;Ha, GH;Haagsma, JA;Hachinski, V;Hafezi-Nejad, N;Bidgoli, HH;Hagos, TB;Haile, MT;Hailegiyorgis, TT;Hailu, GB;Haj-Mirzaian, A;Haj-Mirzaian, A;Hamadeh, RR;Hamidi, S;Hankey, GJ;Harb, HL;Harikrishnan, S;Haririan, H;Haro, JM;Hasan, M;Hassankhani, H;Hassell, HY;Havmoeller, R;Hawley, CN;Hay, Sl;He, Y;Hedayatizadeh-Omran, A;Hegazy, MI;Heibati, B;Heidari, B;Heidari, M;Hendrie, D;Henok, A;Heredia-Pi, I;Herteliu, C;Heydarpour, B;Heydarpour, F;Heydarpour, S;Hibstu, DT;Hijar, M;Hoek, HW;Hoffman, DJ;Hole, MK;Rad, EH;Hoogar, P;Horita, N;Hosgood, HD;Hosseini, SM;Hosseinzadeff, M;Hostiuc, A;Hostiuc, S;Hotez, PJ;Hoy, DG;Hsairi, M;Hsiao, T;Hu, G;Huang, JJ;Hughes, C;Huynh, CK;Igumbor, EU;Ikeda, CT;Illesanmi, OS;Iqbal, U;Irvani, SSN;Irvine, CMS;Islam, SMS;Islami, F;Ivers, RQ;Izadi, N;Jacobsen, KH;Jahangiry, L;Jahanmehr, N;Jain, SK;Jakovljevic, M;Jalu, MT;Jamal, AA;James, Sl;Jassal, SK;Javanbakht, M;Jayatilleke, AU;Jeemon, P;Jha, RP;Jha, V;Ji, JS;Johnson, CO;Johnson, SC;Jonas, JB;Jonagaddala, J;Shushtari, ZJ;Joshi, A;Jozwiak, JJ;Jungari, SB;Jurisson, M;Madhanraj, K;Kabir, Z;Kadel, R;Kahsay, A;Kahssay, M;Kalani, R;Kapil, U;Karami, M;Marin, BK;Karanikolos, M;Karimi, N;Karimi, SM;Karimi-Sari, H;Kasaeian, A;Kassa, DH;Kassa, GM;Kassa, TD;Kassa, ZY;Kassebaum, NJ;Katikireddi, SV;Kaul, A;Kawakami, N;Kazemi, Z;Karyani, AK;Kazi, DS;Prakash, KC;Kebede, S;Keiyoro, PN;Kemmer, L;Kemp, GR;Kengne, AP;Keren, A;Kesavachandran, CN;Khader, YS;Khafaei, B;Khafaie, MA;Khajavi, A;Khalid, N;Khalil, IA;Khan, EA;Khan, MS;Khan, MA;Khang, Y-H;Khanna, T;Khater, MM;Khatony, A;Khazaeipour, Z;Khazaie, H;Khoja, AT;Khosravi, A;Khosravi, MH;Khubchandani, J;Kiadaliri, AA;Kiarie, HW;Kibret, GD;Kiirithio, DN;Kim, D;Kim, JY;Kim, Y-E;Kim, YJ;Kimokoti, RW;Kinfu, Y;Kinra, S;Kisa, A;Kissimova-Skarbek, K;Kissoo, N;Kivimaki, M;Kocamik, JM;Kochhar, S;Kokubo, Y;Kolola, T;Kopec, JA;Kosek, MN;Kosen, S;Koul, PA;Koyanagi, A;Kravchenko, MA;Krishan, K;Krohn, KJ;Defo, BK;Bicer, BK;Kudom, AA;Kulikoff, XR;Kumar, GA;Kumar, M;Kumar, P;Kutz, MJ;Kyu, HH;Lachat, C;Lad, DP;Lad, SD;Lafranconi, A;Lagat, AK;Lal, DK;Lalloo, R;Lam, H;Lami, FH;Lamichhane, P;Lan, Q;Lang, JJ;Lansingh, VC;Lansky, S;Larson, HJ;Larsson, A;Laryea, DO;Lassi, ZS;Latifi, A;Lau, KM-M;Laxmaiah, A;Lazarus, JV;Leasher, JL;Lebedev, G;Ledesma, JR;Lee, JB;Lee, PH;Leever, AT;Leigh, J;Leinsalu, M;Leshargie, CT;Leung, J;Lewycka,

S;Li, S;Li, X;Li, Y;Liang, J;Hang, X;Liben, ML;Lim, L-L;Limenih, MA;Linn, S;Liu, S;Liu, Y;Lodha, R;Logroscino, G;Lopez, AD;Lorkowski, S;Lotufo, PA;Lucchesi, LR;Lyons, RA;Macarayan, ERK;Mackay, MT;Maddison, ER;Madotto, F;Maghavani, DP;Magis-Rodriguez, C;Mahotra, NB;Majdan, M;Majdzadeh, R;Majeed, A;Malekzadeh, R;Malta, DC;Mamun, AA;Manda, A-L;Rano-Filho, LGM;Mangalam, S;Manguerra, H;Mansournia, MA;Mapoma, CC;Maravilla, JC;Marcenes, W;Marks, A;Martin, RV;Martins, SCO;Martins-Melo, FR;Madopullo, I;Mashamba-Thompson, TP;Massenburg, BB;Mathin, MR;Maulik, PK;Mazidi, M;McAlinden, C;McGrath, JJ;McKee, M;McMahon, BJ;Mehata, S;Mehndiratta, MM;Mehrotra, R;Mehta, KM;Mehta, V;Mejia-Rodriguez, F;Mekonen, T;Mekonnen, TCC;Meles, HG;Melese, A;Melku, M;Memiah, PTN;Memish, ZA;Mendoza, W;Mengistu, DT;Mengistu, G;Mensah, GA;Mensink, GBM;Mereta, ST;Meretoja, A;Meretoja, TJ;Mestrovic, T;Mezgebe, HB;Miazgowski, B;Miazgowski, T;Millea, AI;Miller, TR;Miller-Petrie, MK;Milne, GJ;Mini, GK;Minnig, SP;Mirabi, P;Mirarefin, M;Mintakhimoty, EM;Misganaw, AT;Mitchell, PB;Moazen, B;Moghadamnia, AA;Mohajer, B;Mohammad, KA;Mohammadi, M;Mohammadifard, N;Mohammadnia-Afrouzi, M;Mohammed, MA;Mohammed, S;Mohan, MBV;Mohan, V;Mohebi, F;Moltra, M;Mokdad, AH;Molokhia, M;Monasta, L;Montanez, JC;Moosazadeh, M;Moradi, G;Moradi, M;Moradi-Lakeh, M;Moradinazar, M;Moraga, P;Morawska, L;Morgado-da-Costa, J;Morisaki, N;Morrison, SD;Mosapour, A;Moschos, MM;Mountjoy-Venning, WC;Mouodi, S;Mousavi, SM;Muche, AA;Muchie, KF;Mueller, UO;Muhammed, OSS;Mukhopadhyay, S;Mullany, EC;Muller, K;Mumford, JE;Murhekar, M;Murthy, GVS;Murthy, S;Musa, J;Musa, KI;Mustafa, G;Muthupandian, S;Nabhan, AF;Nachega, JB;Nagarajan, AJ;Nagel, G;Naghavi, M;Naheed, A;Nahvijou, A;Naidoo, K;Naik, G;Naik, N;Najafi, F;Naldi, L;Nam, HS;Nangia, V;Nansseu, JR;Nascimento, BR;Nawaz, H;Neamati, N;Negoi, I;Negoi, RI;Neupane, S;Newton, CRJ;Ngalesoni, FN;Ngunjiri, JW;Anh, N;Nguyen, G;Ha, N;Huong, LTN;Huong, TN;Minh, N;Nichols, E;Nigatu, SG;Ningrum, DNA;Nirayo, YL;Nisar, MI;Nixon, MR;Nolutshungu, N;Nomura, M;Norheim, OF;Noroozi, M;Norrving, B;Noubiap, JJ;Nouri, HR;Shiadeh, MN;Nowroozi, MR;Nyasulu, PS;Obermeyer, CM;Ofori-Asenso, R;Ogah, OS;Ogbo, FA;Oh, I-H;Okoro, A;Oladimeji, KE;Oladimeji, O;Olagunju, AT;Olagunju, T;Olivares, PR;Olsen, HE;Olusanya, BO;Olusanya, JO;Ong, KL;Ong, SK;Oommen, AM;Opio, JN;Oren, E;Oros, A;Ortega-Altamirano, DDV;Ortiz, A;Ortiz, JR;Ortiz-Panozo, E;Ota, E;Otstavnov, SS;Owolabi, MO;Mahesh, PA;Pakhale, S;Pakhare, AP;Pan, W-H;Pana, A;Panda, BK;Panda-Jonas, S;Pandian, JD;Papantoniou, N;Park, E-K;Parry, CDH;Parsian, H;Patel, S;Pati, S;Patle, A;Patton, GC;Paturi, VR;Paudel, D;Paulson, KR;Pearce, N;Peprah, EK;Pereira, DM;Perico, N;Pervaiz, A;Pesudovs, K;Petri, WA;Petzold, M;Phillips, MR;Pigott, DM;Pillay, JD;Pirsahab, M;Pletcher, M;Pond, CD;Postma, MJ;Pourshams, A;Poustchi, H;Prabhakaran, D;Prakash, S;Prasad, N;Purcell, CA;Pyakurel, M;Qorbani, M;Quansah, R;Radfar, A;Rafay, A;Rafiei, A;Rahim, F;Rahimi, K;Rahimi-Movaghar, M;Rahimi-Movaghar, V;Rahman, M;Rahman, KS;Rahman, MHU;Rahman, MA;Rahman, SU;Rai, RK;Rajati, F;Rajsic, S;Ram, U;Rana, SM;Ranabhat, CL;Ranjan, P;Rasella, D;Rawaf, DL;Rawaf, S;Razo-Garcia, C;Reddy, KS;Reiner, RC;Reis, C;Reitsma, MB;Remuzzi, G;Renzaho, AMN;Resnikoff, S;Reynales-Shigematsu, LM;Rezaei, S;Rezaeian, S;Rezai, MS;Riahi, SM;Ribeiro, ALP;Rios-Blancas, MJ;Roba, KT;Roberts, NLS;Roever, L;Ronfani, L;Roshandel, G;Rostami, A;Roth, GA;Roy, A;Rubagotti, E;Ruhago, GM;Sabde, YD;Sachdev, PS;Saddik, B;Sadeghi, E;Safari, H;Safari, Y;Safari-Faramani, R;Safdarian, M;Safi, S;Safiri, S;Sagar, R;Sahebkar, A;Sahraian, MA;Sajadi, HS;Salam, N;Salama, JS;Salamat, P;Saldanha, RDF;Saleem, Z;Salimi, Y;Salimzadeh, H;Salomon, JA;Salvi, SS;Satz, I;Sambala, EZ;Samy, AM;Sanabria, J;Nino, MDS;Santos, IS;Milicevic, MMS;Jose, BPS;Sardana, M;Sarker, AR;Sarrafzadegan, N;Sartorius, B;Sarvi, S;Sathian, B;Satpathy, M;Savic, M;Sawant, AR;Sawhney, M;Saxena, S;Saylan, M;Sayyah, M;Schaeffner, E;Schmidt, MI;Schneider, IJC;Schotffer, B;Schutte,

AE;Schwebel, DC;Schwendicke, F;Seedat, S;Sekerija, M;Sepanlou, SG;Servan-Mori, E;Seyedmousavi, S;Shabaninejad, H;Shackelford, KA;Shafieesabet, A;Shaheen, AA;Shaikh, MA;Shams-Beyranvand, M;Shamsi, MB;Shamsizadeff, M;Sharafi, H;Sharafi, K;Sharif, M;Sharif-Alhoseini, M;Sharma, J;Sharma, R;Sharma, SK;She, J;Sheikh, A;Shey, MS;Shi, P;Shibuya, K;Shields, C;Shifa, GT;Shiferaw, MS;Shigematsu, M;Shin, R;Shirkoohi, R;Shirude, S;Shishani, K;Shiue, I;Shokraneh, F;Shoman, H;Shrime, MG;Shukla, SR;Si, S;Siabani, S;Sibai, AM;Siddiqi, TJ;Sigfusdottir, TD;Silpakit, N;Silva, DAS;Silva, JP;da Silva, NT;Silveira, DGA;Singh, JA;Singh, NP;Singh, OP;Singh, PK;Singh, V;Sinha, DN;Skiadaresi, E;Sliwa, K;Smith, AE;Smith, M;Soares Filho, AM;Sobaih, BH;Sobhani, S;Soljak, M;Soofi, M;Soosaraei, M;Sorensen, RJD;Soriano, JB;Soshnikov, S;Soyiri, IN;Spinelli, A;Sposato, LA;Sreeramareddy, CT;Srinivasan, RG;Srinivasan, V;Stanaway, JD;Starodubov, VI;Stathopoulou, V;Steckling, N;Stein, DJ;Stewart, LG;Stockfelt, L;Stokes, MA;Straif, K;Sudaryanto, A;Sufiyan, MB;Sunguya, BF;Sur, PJ;Sutradhar, I;Sykes, BL;Sylaja, PN;Sylte, D;Szoeki, CEI;Tabares-Seisdedos, R;Tabuchi, T;Tadakamatha, SK;Tamirat, KS;Tandon, N;Tanser, FC;Tassew, AA;Tassew, SG;Tavakkoli, M;Taveira, N;Tawye, NT;Tehrani-Banihashemi, A;Tekalign, TG;Tekle, MG;Temesgen, H;Temsah, M-H;Temsah, O;Terkawi, AS;Teshale, MY;Teshome, DF;Tessema, B;Teweldemedhin, M;Thakur, JS;Thankappan, KR;Theis, A;Thintnavukkarasu, S;Thomas, LA;Thomas, N;Thomson, AJ;Thrift, AC;Tilahun, B;To, QG;Tobe-Gai, R;Tonelli, M;Topor-Madry, R;Torre, AE;Tortajada-Girbes, M;Tovani-Palone, MR;Towbin, JA;Bach, XT;Khanh, BT;Tung, TT;Tripathy, SP;Troeger, CE;Truelsen, TC;Tsadik, AG;Car, LT;Tuzcu, EM;Tymeson, HD;Ukwaja, KN;Ullah, I;Updike, RI;Usman, MS;Uthman, OA;Vaduganathan, M;Vaezi, A;Vaidya, G;Valdez, PR;van Donkelaar, A;Varavikova, E;Vasankari, TJ;Venketasubramanian, N;Vidavalur, R;Villafaina, S;Violante, FS;Vladimirov, SK;Vlassov, V;Vollmer, S;Vollset, SE;Vbs, T;Vosoughi, K;Vujcic, IS;Wagner, GR;Wagnew, FS;Waheed, Y;Watson, JI;Wang, Y;Wang, Y-P;Wassie, MM;Weiderpass, E;Weintraub, RG;Weiss, J;Weldegebreal, F;Weldegewergs, KG;Werdecker, A;Ayaliew, A;West, WTL;Westerman, R;Whisnant, JL;Whiteford, HA;Widecka, J;Widecka, K;Wijeratne, T;Wither, LB;Winkler, AS;Wiyeh, AB;Wiysonge, CS;Wolde, HF;Wolfe, CDA;Wu, S;Xavier, D;Xu, G;Xu, R;Yadollahpour, A;Jabbari, SHY;Yakob, B;Yamada, T;Tan, LL;Yano, Y;Yaseri, M;Yasin, YJ;Ye, P;Tearwood, JA;Yeshaneh, A;Yimer, EM;Yip, P;Yirsaw, BD;Yisma, E;Yonemoto, N;Tonga, G;Toon, S-J;Yotebieng, M;Younis, MZ;Yousefifard, M;Yu, C;Bin Zaman, S;Zamani, M;Zara, Z;Zavala-Arciniega, L;Zegeye, DT;Zegeye, EA;Zelege, AJ;Zendejdel, K;Zerfit, TA;Zhang, AL;Zhang, X;Zhou, M;Zhu, J;Zimsen, SRM;Zodpey, S;Zoeckler, L;Zucker, I;Zuhlke, LJJ;Lim, SS;Murray, CJL

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# Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related Sustainable Development Goals for 195 countries and territories: a systematic analysis for the Global Burden of Disease Study 2017

GBD 2017 SDG Collaborators\*



## Summary

**Background** Efforts to establish the 2015 baseline and monitor early implementation of the UN Sustainable Development Goals (SDGs) highlight both great potential for and threats to improving health by 2030. To fully deliver on the SDG aim of “leaving no one behind”, it is increasingly important to examine the health-related SDGs beyond national-level estimates. As part of the Global Burden of Diseases, Injuries, and Risk Factors Study 2017 (GBD 2017), we measured progress on 41 of 52 health-related SDG indicators and estimated the health-related SDG index for 195 countries and territories for the period 1990–2017, projected indicators to 2030, and analysed global attainment.

**Methods** We measured progress on 41 health-related SDG indicators from 1990 to 2017, an increase of four indicators since GBD 2016 (new indicators were health worker density, sexual violence by non-intimate partners, population census status, and prevalence of physical and sexual violence [reported separately]). We also improved the measurement of several previously reported indicators. We constructed national-level estimates and, for a subset of health-related SDGs, examined indicator-level differences by sex and Socio-demographic Index (SDI) quintile. We also did subnational assessments of performance for selected countries. To construct the health-related SDG index, we transformed the value for each indicator on a scale of 0–100, with 0 as the 2·5th percentile and 100 as the 97·5th percentile of 1000 draws calculated from 1990 to 2030, and took the geometric mean of the scaled indicators by target. To generate projections through 2030, we used a forecasting framework that drew estimates from the broader GBD study and used weighted averages of indicator-specific and country-specific annualised rates of change from 1990 to 2017 to inform future estimates. We assessed attainment of indicators with defined targets in two ways: first, using mean values projected for 2030, and then using the probability of attainment in 2030 calculated from 1000 draws. We also did a global attainment analysis of the feasibility of attaining SDG targets on the basis of past trends. Using 2015 global averages of indicators with defined SDG targets, we calculated the global annualised rates of change required from 2015 to 2030 to meet these targets, and then identified in what percentiles the required global annualised rates of change fell in the distribution of country-level rates of change from 1990 to 2015. We took the mean of these global percentile values across indicators and applied the past rate of change at this mean global percentile to all health-related SDG indicators, irrespective of target definition, to estimate the equivalent 2030 global average value and percentage change from 2015 to 2030 for each indicator.

**Findings** The global median health-related SDG index in 2017 was 59·4 (IQR 35·4–67·3), ranging from a low of 11·6 (95% uncertainty interval 9·6–14·0) to a high of 84·9 (83·1–86·7). SDG index values in countries assessed at the subnational level varied substantially, particularly in China and India, although scores in Japan and the UK were more homogeneous. Indicators also varied by SDI quintile and sex, with males having worse outcomes than females for non-communicable disease (NCD) mortality, alcohol use, and smoking, among others. Most countries were projected to have a higher health-related SDG index in 2030 than in 2017, while country-level probabilities of attainment by 2030 varied widely by indicator. Under-5 mortality, neonatal mortality, maternal mortality ratio, and malaria indicators had the most countries with at least 95% probability of target attainment. Other indicators, including NCD mortality and suicide mortality, had no countries projected to meet corresponding SDG targets on the basis of projected mean values for 2030 but showed some probability of attainment by 2030. For some indicators, including child malnutrition, several infectious diseases, and most violence measures, the annualised rates of change required to meet SDG targets far exceeded the pace of progress achieved by any country in the recent past. We found that applying the mean global annualised rate of change to indicators without defined targets would equate to about 19% and 22% reductions in global smoking and alcohol consumption, respectively; a 47% decline in adolescent birth rates; and a more than 85% increase in health worker density per 1000 population by 2030.

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\*Collaborators are listed at the end of the paper

Correspondence to:  
Prof Rafael Lozano, University of Washington, Institute for Health Metrics and Evaluation, Seattle, WA 98121, USA  
rlozano@uw.edu

**Interpretation** The GBD study offers a unique, robust platform for monitoring the health-related SDGs across demographic and geographic dimensions. Our findings underscore the importance of increased collection and analysis of disaggregated data and highlight where more deliberate design or targeting of interventions could accelerate progress in attaining the SDGs. Current projections show that many health-related SDG indicators, NCDs, NCD-related risks, and violence-related indicators will require a concerted shift away from what might have driven past gains—curative interventions in the case of NCDs—towards multisectoral, prevention-oriented policy action and investments to achieve SDG aims. Notably, several targets, if they are to be met by 2030, demand a pace of progress that no country has achieved in the recent past. The future is fundamentally uncertain, and no model can fully predict what breakthroughs or events might alter the course of the SDGs. What is clear is that our actions—or inaction—today will ultimately dictate how close the world, collectively, can get to leaving no one behind by 2030.

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#### Research in context

##### Evidence before this study

Measuring country progress on the UN's Sustainable Development Goals (SDGs) has been an important international priority since the SDGs were introduced in 2015. The UN, the Sustainable Development Solutions Network, WHO, and the World Bank also report on the SDGs, but their analyses do not consistently measure indicators for each location and year. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2015 estimated 33 health-related SDG indicators and the overall health-related SDG index from 1990 to 2015 for 188 countries. In GBD 2016, the number of indicators included was expanded to 37, and projections of health-related SDG achievement in 2030 were estimated for the first time. The ability of decision makers, particularly at the national level, to adequately monitor progress on the health-related SDGs and budget and plan for the future is potentially hampered by the scarcity of disaggregated data, such as by subnational unit, sex, and socioeconomic level. Complete estimates of SDG progress at these levels are needed to identify, and target programmes to, the populations that are most at risk of falling behind.

##### Added value of this study

GBD 2017 provides consistent, comparably generated estimates of the health-related SDG indicators for 195 countries and territories from 1990 to 2017. Additionally, GBD 2017 provides, for the first time, estimates of health-related SDGs at the subnational level for select countries and by sex. Newly estimated indicators in GBD 2017 include health worker density per 1000 population (SDG indicator 3.c.1), sexual violence by non-intimate partners (SDG indicator 5.2.2), and population census status (SDG indicator 17.19.2a), as well as disaggregation of SDG indicator 16.1.3 into prevalence of physical violence (SDG indicator 16.1.3a) and sexual violence (SDG indicator 16.1.3c) following the March, 2018, refinements accepted by the UN Statistical Commission. Measurement improvements included reporting on prevalence of current smoking rather

than of daily smoking to better align with the UN's definition and internally consistent, systematic estimation of adolescent birth rates within the broader GBD study. We used a forecasting platform that systematically captures the effects of independent drivers of population health into the future to generate projections through 2030. On the basis of past trends, we assessed country-level probabilities of attainment for SDG indicators with defined targets. We also calculated the rates of change required to meet defined SDG targets at the global level from 2015 to 2030, and then compared them to annualised rates of change observed at the country level from 1990 to 2015; this analysis provided a way of benchmarking the pace of progress needed to meet ambitious SDG aims with what the world has achieved in the past. We then applied the mean percentile of the global required rates of change to all SDG indicators, providing a historically grounded foundation to evaluate progress for indicators without explicit targets and the relative feasibility of current ones.

##### Implications of all the available evidence

Most countries were projected to improve their health-related SDG index scores by 2030, although our results revealed gaps in potential progress at and beyond the national level. This information is urgently needed to inform strategies for attaining SDG targets, which for many countries will require rates of progress that are faster than rates achieved in the recent past. Most countries already have national action plans in place for, and are in a better position to meet indicator targets that have origins in, the Millennium Development Goals, whereas the SDGs have not been similarly operationalised in many national policies. In the remaining years of the SDG era, it is crucial that governments and international institutions invest in and implement SDG-related programmes and continue to monitor inequalities in the health-related SDGs within populations to truly deliver on the promise of leaving no one behind.

## Introduction

During the early years of implementation of the UN's Sustainable Development Goals (SDGs), which were adopted in 2015,<sup>1</sup> various international efforts have sought to galvanise faster progress towards the SDGs' bold aims. A recent example includes WHO's 13th General Programme of Work (GPW13) for 2019–23,<sup>2</sup> which involves an ambitious agenda of measurable goals and interconnected strategies to ensure healthy lives and wellbeing for people of all ages. The GPW13 has three strategic priorities that will be measured by existing, or composites of existing, SDG indicators: achieving universal health coverage (UHC), addressing health emergencies, and promoting healthier populations.<sup>3</sup>

We are in the third year of the SDG era, and progress towards the world-changing aspirations of the SDGs remains a gradual, ongoing process. Although, for some indicators, many countries have maintained the pace of progress made during the era of the Millennium Development Goals, for other indicators, countries have seen gains slow.<sup>4–7</sup> These trends underscore the need to focus existing programmes and policies on the expanded scope of the SDG agenda. For instance, some countries in sub-Saharan Africa and Latin America will need to hasten progress against non-communicable diseases (NCDs) if corresponding SDG targets are to be met, and NCDs are a major component of the GPW13.<sup>8,9</sup> Although NCD prevention is a UN policy priority,<sup>10</sup> and many evidence-based policies and programmes exist to target NCDs, substantial implementation gaps remain. *The Lancet* has called for 2018 to be the year for action against NCDs,<sup>9,11,12</sup> and in the report *Time to Deliver*,<sup>5,6</sup> the WHO Independent High-Level Commission on Noncommunicable Diseases declared there is no excuse not to act.

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2015 was the first GBD effort to measure the health-related SDGs, producing estimates for 33 health-related SDG indicators and generating an overall measure, the health-related SDG index, from 1990 to 2015 for 188 countries.<sup>13</sup> For GBD 2016, this effort was expanded to include four additional SDG indicators, as well as projections of SDG attainment through 2030 based on past trends.<sup>5</sup> GBD 2016 also improved methods for measuring UHC service coverage.<sup>5</sup> Other organisations measure a subset of the health-related SDG indicators, but not consistently across locations and years.<sup>4,6,7</sup>

Although national SDG analyses can be useful for guiding health policy, the most vulnerable populations within countries are still at risk of being left behind. Country-level measures of population health likely mask disparities between and within subnational administrative divisions, particularly in low-income and middle-income countries.<sup>14–18</sup> National governments need subnational data to inform the localisation of global SDG policies and programmes, allowing decision makers to

better target resource allocation and service delivery.<sup>19,20</sup>

In many places, males and females also experience disparate risk exposures and corresponding health outcomes,<sup>21</sup> yet SDG reports do not typically provide data disaggregated by sex, with the exception of those on smoking prevalence. The Inter-agency and Expert Group on Sustainable Development Goal Indicators has requested that metadata be disaggregated by sex for 19 health-related SDG indicators,<sup>22</sup> and more detailed data will need to be collected and monitored to assess progress, identify high-risk populations, and develop targeted approaches to prevention and treatment. Although valuable, even data at this level might not be sufficient to capture inequalities underlying macro-level trends. Finally, in the absence of clearly defined targets, progress on several health-related SDG indicators cannot be benchmarked against SDG aims. Target setting is a complex process that requires a delicate balance of technical and political inputs; yet, without established targets, galvanising greater political and financial commitments to address health needs during the SDG era could be challenging.

In this study, we provide updated estimates for 41 of 52 health-related SDG indicators and the overall health-related SDG index for 195 countries and territories. For ten indicators, we compare progress from 1990 to 2017 by sex and by Socio-demographic Index (SDI), a composite measure of overall development. Using past trends, we project global progress and analyse attainment of the health-related SDGs through 2030. These estimates will provide a benchmark against which the feasibility of attaining SDG targets by 2030 can be assessed on the basis of what countries have achieved in the past. Compared with GBD 2016, GBD 2017 includes four additional health-related SDG indicators and improves the measurement of some previously included indicators. This analysis can support global efforts, such as the monitoring of the GPW13, and national-level decision making by international institutions, policy makers, and national governments who implement the health-related SDGs.

## Methods

### Overview of GBD

Each year, the GBD study produces age-specific, sex-specific, and location-specific estimates of all-cause and cause-specific mortality, non-fatal outcomes, overall disease burden (ie, disability-adjusted life-years), and risk factor exposure and attributable burden from 1990 to the current study year.

This analysis of the health-related SDGs is based on GBD 2017 estimates. Broader GBD 2017 methods are described elsewhere,<sup>21,23–27</sup> while further detail on data sources and estimation approaches used for this analysis are available in appendix 1 (part 1). We used previously established GBD methods to generate indicator-specific estimates for 1990–2017, including the Cause of Death

See Online for appendix 1

Ensemble model for causes of death,<sup>23,28</sup> DisMod-MR for many non-fatal causes,<sup>26,29</sup> and spatiotemporal Gaussian process regression for most risk factor exposures, measures of intervention coverage, and other SDG indicators (eg, well-certified death registration [SDG indicator 17.19.2c]).<sup>21,30</sup>

Each year, GBD includes subnational analyses for a few new countries and continues to provide subnational estimates for countries that were added in previous cycles. Subnational estimation in GBD 2017 includes five new countries (Ethiopia, Iran, New Zealand, Norway, Russia) and countries previously estimated at subnational levels (GBD 2013: China, Mexico, and the UK [regional level]; GBD 2015: Brazil, India, Japan, Kenya, South Africa, Sweden, and the USA; GBD 2016: Indonesia and the UK [local government authority level]). All analyses are at the first level of administrative organisation within each country except for New Zealand (by Māori ethnicity), Sweden (by Stockholm and non-Stockholm), and the UK (by local government authorities). All subnational estimates for these countries were incorporated into model development and evaluation as part of GBD 2017. To meet data use requirements, in this publication we present all subnational estimates excluding those pending publication (Brazil, India, Japan, Kenya, Mexico, Sweden, the UK, and the USA); these results are presented in appendix tables and figures (appendix 2). Subnational estimates for countries with populations larger than 200 million (as measured with our most recent year of published estimates) that have not yet been published elsewhere are presented wherever estimates are illustrated with maps, but are not included in data tables.

See Online for appendix 2

The GBD study uses standardised and replicable methods that comply with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER).<sup>31</sup> Analyses were done with R version 3.4.4, Python version 2.7.14, or Stata version 13.1. The entire GBD time series is updated annually with improved methods and data sources, and thus GBD 2017 findings, including the SDG analysis presented here, supersede all previous GBD publications.

### Indicators, definitions, and measurement approaches

The health-related SDG indicators are shown in table 1. GBD 2017 assesses four more indicators than assessed in GBD 2016. The first is health worker density (SDG indicator 3.c.1), which is defined by the UN as health workers per 1000 population, by cadre of health worker. For this analysis, we report estimates for three main groups of health workers: physicians, nurses and midwives, and pharmacists. We used International Standard Classification of Occupations (ISCO) 88 to map cadres of health workers from multiple data sources and coding systems, resulting in comparable and consistently defined groupings of health workers over time and across locations (appendix 1 part 1).

The second new indicator is sexual violence by non-intimate partners (SDG indicator 5.2.2), which is defined as the prevalence of females aged 15 years and older who have been subjected to sexual violence by non-intimate partners in the past 12 months. The third is the separate reporting of the prevalence of physical and sexual violence (SDG indicator 16.1.3). In March, 2018, the UN Statistical Commission approved refinements to SDG indicator 16.1.3, such that the indicator is now defined as the “proportion of population subjected to (a) physical violence, (b) psychological violence, and (c) sexual violence in the previous 12 months”.<sup>32,33</sup> Following the GBD precedent of measuring each component of an SDG indicator (eg, reporting separately on child wasting and overweight [SDG indicators 2.2.2a and 2.2.2b] and on sanitation and access to handwashing facilities [SDG indicators 6.2.1a and 6.2.1b]),<sup>5,13</sup> we report the prevalence of physical violence and that of sexual violence separately. Owing to measurement challenges and data sparsity, we did not measure the prevalence of psychological violence.

The final new indicator is population census status (SDG indicator 17.19.2a), which was defined as covered if a location had conducted a population and housing census within the past 10 years or had an established population registry that routinely captured nationally representative demographic information (appendix 1 part 1). To assess population census status, we used data compiled for GBD 2017 population estimates,<sup>24</sup> as well as all available data on population census implementation since 1980 and documentation of population registries.

As well as adding new indicators, we have improved the measurement of several previously reported indicators. For smoking prevalence (SDG indicator 3.a.1), we now report prevalence of current smoking (daily and occasional smokers) rather than only daily smoking to better align with the UN’s definition (appendix 1 part 1). For vaccine coverage (SDG indicator 3.b.1), we include all eight vaccines in the aggregate measure for each location-year, rather than limiting the aggregate to vaccines expressly included in national vaccine schedules. Additionally, we now take the arithmetic, rather than the geometric, mean across the eight vaccines. These revisions allow better comparability across locations over time, avoid inadvertently penalising countries for introducing and scaling up new vaccines, and provide a better reflection of overall vaccine coverage for target populations.

The UHC service coverage index includes nine measures of coverage for a subset of interventions for communicable diseases and maternal and child health and the 32 causes that comprise the Healthcare Access and Quality (HAQ) Index (appendix 1 part 1). The HAQ Index is an overall measure of health-care access and quality based on risk-standardised death rates or mortality-to-incidence ratios from causes amenable to health care.<sup>34</sup> Following updated HAQ methods,<sup>34</sup> we used mortality-to-incidence ratios for cancers rather than risk-standardised death rates for the UHC

|  | Health-related SDG indicator                                     | Indicator definition  | Currently measured by GBD | Further details   | SDG target   | SDG target used in this analysis  |
|--|--|---|---------------------------|---|--|-----------------------------------|
| <b>Goal 1: End poverty in all its forms everywhere</b>   |  |   |                           |   |  |                                   |
| Target 1.5: By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters  | Disaster mortality (1.5.1; same as indicators 11.5.1 and 13.1.1) | Death rate due to exposure to forces of nature, per 100 000 population  | Yes                       | Existing datasets do not comprehensively measure missing persons and people affected by natural disasters; we thus report deaths due to exposure to forces of nature  | Undefined  | ..                                |
| <b>Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture</b>   |  |   |                           |   |  |                                   |
| Target 2.2: By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children younger than 5 years, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older people | Child stunting (2.2.1)   | Prevalence of stunting in children younger than 5 years, %  | Yes                       | Stunting is defined as below -2 SDs from the median height-for-age of the WHO reference population. No indicator modifications are required   | Eliminate by 2030  | ≤0.5%                             |
| Target 2.2 (as above)  | Child wasting (2.2.2a)   | Prevalence of wasting in children younger than 5 years, %   | Yes                       | We have separated reporting for indicator 2.2.2 into wasting (2.2.2a) and overweight (2.2.2b). Wasting is defined as below -2 SDs from the median weight-for-height of the WHO reference population   | Eliminate by 2030  | ≤0.5%                             |
| Target 2.2 (as above)  | Child overweight (2.2.2b)  | Prevalence of overweight in children aged 2–4 years, %  | Yes                       | We have separated reporting for indicator 2.2.2 into wasting (2.2.2a) and overweight (2.2.2b). We used the IOTF thresholds because the WHO cutoff at age 5 years can lead to an artificial shift in prevalence estimates when the analysis covers more age groups. Furthermore, considerably more studies use IOTF cutoffs, which allowed us to build a larger database for estimating child overweight | Eliminate by 2030  | ≤0.5%                             |
| <b>Goal 3: Ensure healthy lives and promote wellbeing for all at all ages</b>  |  |   |                           |   |  |                                   |
| Target 3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 livebirths   | Maternal mortality ratio (3.1.1)                                 | Maternal deaths per 100 000 livebirths in females aged 10–54 years  | Yes                       | No indicator modifications required   | Reduce to <70 deaths per 100 000 livebirths by 2030      | <70 deaths per 100 000 livebirths |
| Target 3.1 (as above)  | Skilled birth attendance (3.1.2)                                 | Proportion of births attended by skilled health personnel (doctors, nurses, midwives, or country-specific medical staff [eg, clinical officers]), % | Yes                       | No indicator modifications required   | Universal access (100%)                                  | ≥99%                              |
| Target 3.2: By 2030, end preventable deaths of newborns and children younger than 5 years, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 livebirths and under-5 mortality to at least as low as 25 per 1000 livebirths                    | Under-5 mortality (3.2.1)  | Probability of dying before age 5 years, per 1000 livebirths  | Yes                       | No indicator modifications required   | Reduce to 25 deaths per 1000 livebirths or lower by 2030 | ≤25 deaths per 1000 livebirths    |
| Target 3.2 (as above)  | Neonatal mortality (3.2.2)                                       | Probability of dying during the first 28 days of life, per 1000 livebirths  | Yes                       | No indicator modifications required   | Reduce to 12 deaths per 1000 livebirths or lower by 2030 | ≤12 deaths per 1000 livebirths    |
| Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases   | HIV incidence (3.3.1)  | Age-standardised rate of new HIV infections per 1000 population   | Yes                       | We report HIV incidence of all populations and in terms of age-standardised rates   | Eliminate by 2030  | ≤0.005 per 1000 population        |
| Target 3.3 (as above)  | Tuberculosis incidence (3.3.2)                                   | Age-standardised rate of tuberculosis cases per 100 000 population  | Yes                       | No indicator modifications required   | Eliminate by 2030  | ≤0.5 per 100 000 population       |

(Table 1 continues on next page)

|  | Health-related SDG indicator                                   | Indicator definition   | Currently measured by GBD | Further details  | SDG target                  | SDG target used in this analysis |
|--|--|--|---------------------------|--|-----------------------------|----------------------------------|
| (Continued from previous page)   |  |  |                           |  |                             |                                  |
| Target 3.3 (as above)  | Malaria incidence (3.3.3)                                      | Age-standardised rate of malaria cases per 1000 population   | Yes                       | No indicator modifications required  | Eliminate by 2030           | ≤0.005 per 1000 population       |
| Target 3.3 (as above)  | Hepatitis B incidence (3.3.4)                                  | Age-standardised rate of hepatitis B incidence per 100 000 population  | Yes                       | No indicator modifications required  | Undefined                   | ..                               |
| Target 3.3 (as above)  | Neglected tropical diseases prevalence (3.3.5)                 | Age-standardised prevalence of the sum of 15 neglected tropical diseases, %  | Yes                       | People requiring interventions against neglected tropical diseases is not well defined; thus, this indicator is revised to the sum of the prevalence of 15 neglected tropical diseases currently measured in the GBD study: human African trypanosomiasis, Chagas disease, cystic echinococcosis, cysticercosis, dengue, food-borne trematodiasis, Guinea worm disease, intestinal nematode infections, leishmaniasis, leprosy, lymphatic filariasis, onchocerciasis, rabies, schistosomiasis, and trachoma  | Eliminate by 2030           | ≤0.5%                            |
| Target 3.4: By 2030, reduce by one-third premature mortality from NCDs through prevention and treatment and promote mental health and wellbeing  | NCD mortality (3.4.1)  | Age-standardised death rate due to cardiovascular disease, cancer, diabetes, and chronic respiratory disease in populations aged 30–70 years, per 100 000 population | Yes                       | No indicator modifications required  | Reduce by one-third by 2030 | Reduce by one-third              |
| Target 3.4 (as above)  | Suicide mortality (3.4.2)                                      | Age-standardised death rate due to self-harm, per 100 000 population   | Yes                       | No indicator modifications required  | Reduce by one-third by 2030 | Reduce by one-third              |
| Target 3.5: Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol   | Substance abuse coverage (3.5.1)                               | Coverage of treatment interventions (pharmacological, psychosocial, and rehabilitation and aftercare services) for substance use disorders, %                        | No                        | Prevalence of specific substance use disorders (opioid, cocaine, amphetamine, and cannabis use disorders), as well as alcohol use disorders, are presently estimated as part of GBD. Efforts to extract and synthesise data on coverage of specific interventions (eg, opioid substitution therapy) are currently in progress as part of the broader GBD study   | Undefined                   | ..                               |
| Target 3.5 (as above)  | Alcohol use (3.5.2)  | Risk-weighted prevalence of alcohol consumption, as measured by the SEV for alcohol use, %   | Yes                       | For this indicator, we include three categories of alcohol consumption because national alcohol consumption per capita does not capture the distribution of use. The SEV for alcohol use is based on two primary dimensions: individual-level drinking (current drinkers and lifetime abstainers, and alcohol consumption by age and sex) and population-level consumption (litre per capita of pure alcohol stock). The SEV then weights these categories with their corresponding relative risks, which translates to a risk-weighted prevalence on a scale of 0% (no risk in the population) to 100% (the entire population experiences maximum risk associated with alcohol consumption) | Undefined                   | ..                               |
| Target 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents  | Road injury mortality (3.6.1)                                  | Age-standardised death rate due to road injuries, per 100 000 population   | Yes                       | No indicator modifications required  | Reduce by one-half by 2020  | Reduce by 50%                    |
| Target 3.7: By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes | Family planning need met, modern contraception methods (3.7.1) | Proportion of women of reproductive age (15–49 years) who have their need for family planning satisfied with modern methods, %                                       | Yes                       | No indicator modifications required  | Universal access (100%)     | ≥99%                             |
| Target 3.7 (as above)  | Adolescent birth rate (3.7.2)                                  | Number of livebirths per 1000 females aged 10–14 years or 15–19 years  | Yes                       | No indicator modifications required  | Undefined                   | ..                               |

(Table 1 continues on next page)

service coverage index to better approximate access to quality cancer care. Considerable updates were made to measurement of adolescent birth rate (SDG indicator 3.7.2), which was based on comprehensive estimates of population and fertility from GBD 2017,<sup>24</sup> as well as of fatal discontinuities (mortality due to natural

disasters or conflict and terrorism), among other indicators. Further detail can be found in appendix 1 (part 1) and accompanying GBD 2017 papers.<sup>21,23–27</sup>

We report estimates for all health-related SDG indicators with both sexes combined and sex-specific estimates for HIV incidence (SDG indicator 3.3.1),

|   | Health-related SDG indicator       | Indicator definition  | Currently measured by GBD | Further details  | SDG target                                  | SDG target used in this analysis |
|---|------------------------------------|---|---------------------------|--|---|----------------------------------|
| (Continued from previous page)  |                                    |   |                           |  |   |                                  |
| Target 3.8: Achieve UHC, including financial risk protection, access to quality essential health-care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all | UHC service coverage index (3.8.1) | Coverage of essential health services, as defined by the UHC service coverage index of nine tracer interventions and risk-standardised death rates or mortality-to-incidence ratios from 32 causes amenable to personal health care | Yes                       | Tracer interventions included vaccination coverage (coverage of three doses of DPT3, one dose of measles vaccine, and three doses of the oral polio vaccine or inactivated polio vaccine), met need for family planning with modern contraception methods, antenatal care coverage (one visit and four visits), skilled birth attendance coverage, in-facility delivery rates, and coverage of antiretroviral therapy among people living with HIV. The 32 causes amenable to personal health care, which compose the Healthcare Access and Quality Index, included tuberculosis, diarrhoeal diseases, lower respiratory infections, upper respiratory infections, chronic respiratory diseases, diphtheria, whooping cough, tetanus, measles, maternal disorders, neonatal disorders, colon and rectum cancer, non-melanoma skin cancer, breast cancer, cervical cancer, uterine cancer, testicular cancer, Hodgkin lymphoma, leukaemia, rheumatic heart disease, ischaemic heart disease, cerebrovascular disease, hypertensive heart disease, peptic ulcer disease, appendicitis, hernia, gallbladder and biliary diseases, epilepsy, diabetes, chronic kidney disease, congenital heart anomalies, and adverse effects of medical treatment. We then scaled these 41 individual inputs on a scale of 0–100, with 0 reflecting the worst levels observed between 1990 and 2017 and 100 reflecting the best observed during this time. We took the arithmetic mean of these 41 scaled indicators so as to collectively capture a wide range of essential health services pertaining to reproductive, maternal, newborn, and child health; infectious diseases; NCDs; and service capacity and access | Universal access (100%)                     | ≥99%                             |
| Target 3.8 (as above)   | Financial risk protection (3.8.2)  | Proportion of population with large household expenditures on health as a share of total household expenditure or income, %   | No                        | Comprehensive and comparable datasets on household expenditures on health as a fraction of total household expenditure or income are not currently available across all locations and over time. Efforts to quantify incidence of catastrophic health spending, at both 10% and 25% of total expenditure or income, for the full time series and locations included in the GBD study are currently under way   | <10% or <25% of total expenditure or income | ..                               |
| Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination  | Air pollution mortality (3.9.1)    | Age-standardised death rate attributable to household air pollution and ambient air pollution, per 100 000 population   | Yes                       | No indicator modifications required  | Undefined                                   | ..                               |
| Target 3.9 (as above)   | WaSH mortality (3.9.2)             | Age-standardised death rate attributable to unsafe WaSH, per 100 000 population   | Yes                       | No indicator modifications required  | Undefined                                   | ..                               |
| Target 3.9 (as above)   | Poisoning mortality (3.9.3)        | Age-standardised death rate due to unintentional poisonings, per 100 000 population   | Yes                       | No indicator modifications required  | Undefined                                   | ..                               |
| Target 3.a: Strengthen the implementation of the WHO Framework Convention on Tobacco Control in all countries, as appropriate   | Smoking prevalence (3.a.1)         | Age-standardised prevalence of current smoking in populations aged 10 years and older, %  | Yes                       | We report on populations aged 10 years and older   | Undefined                                   | ..                               |

(Table 1 continues on next page)

tuberculosis incidence (SDG indicator 3.3.2), hepatitis B incidence (SDG indicator 3.3.4), NCD mortality (SDG indicator 3.4.1), suicide mortality (SDG indicator 3.4.2), alcohol use (SDG indicator 3.5.2), road injury mortality (SDG indicator 3.6.1), poisoning mortality (SDG indicator 3.9.3), smoking prevalence (SDG 3.a.1), and homicide (SDG indicator 16.1.1). We selected indicators for sex-specific analysis according to the availability of GBD sex-specific data and the utility of presenting sex-specific data by indicator.

We used SDI,<sup>35</sup> a composite measure of overall development based on rescaled values of fertility, education, and income, to compare performance on the health-related SDGs across quintiles of overall development. For GBD 2017, SDI was updated to include only fertility rates for females younger than 25 years rather than total fertility rates.<sup>24</sup> The GBD 2017 population and fertility analysis found that total fertility demonstrates a U-shaped pattern with SDI at higher levels of development, whereas fertility in females younger than

|   | Health-related SDG indicator                             | Indicator definition  | Currently measured by GBD | Further details  | SDG target                                | SDG target used in this analysis |
|---|--|---|---------------------------|--|---|----------------------------------|
| (Continued from previous page)  |  |   |                           |  |   |                                  |
| Target 3.b: Support the research and development of vaccines and medicines for communicable and NCDs that primarily affect developing countries; provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all | Vaccine coverage (3.b.1)                                 | Coverage of eight vaccines in target populations, %   | Yes                       | Vaccines included DPT3, both doses of measles vaccine (one dose and two doses, reported separately), polio (three doses), hepatitis B (three doses), <i>Haemophilus influenzae</i> type b (three doses), pneumococcal conjugate vaccine (three doses), and rotavirus vaccine (two or three doses). We then used the arithmetic mean of coverage of these eight vaccines to calculate overall vaccine coverage of target populations. For GBD 2017, we made some methodological updates for this measure. We now assess coverage for all eight vaccines for every location-year rather than limiting the aggregate to vaccines expressly included in national vaccine schedules. This revision allows for greater comparability across locations over time and helps to avoid overly penalising countries for introducing and scaling up new vaccines. As a result, we were able to remove the 3 year lag that had previously been used for new vaccine introduction; its original utility was to provide a window in which coverage could be scaled up before it counted towards the aggregate. By replacing all location-year estimates with 0% coverage before a given vaccine's introduction, any amount of scale-up now contributes to improved overall coverage for this indicator. We also now take the arithmetic mean across the eight vaccines rather than the geometric mean to avoid over sensitivity to the 0% estimates for vaccines that have yet to be introduced in a given location-year and to provide a more easily interpretable measure of overall vaccine coverage | Coverage of all target populations (100%) | ≥99%                             |
| Target 3.b (as above)   | Developmental assistance for research and health (3.b.2) | Total net official development assistance to the medical research and basic health sectors  | No                        | Development assistance for health is currently assessed within a comprehensive, comparable analytical framework by source, channel, recipient country, and health focus area from 1990 to 2017; however, funding specifically for medical research (eg, research and development of vaccines and medicines, as described in Target 3.b) is not systematically available across source and recipient countries. Additionally, the appropriate assessment of country-level performance remains unclear (eg, whether countries that receive high levels of developmental assistance for medical research are equivalent, in terms of indicator performance, to countries that disburse high levels of developmental assistance for medical research)  | Undefined                                 | ..                               |
| Target 3.b (as above)   | Essential medicines (3.b.3)                              | Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis, % | No                        | Across all locations and over time, comparable data on the stocking and stock-out rates of essential medicines for all types of facility (hospitals, primary care facilities, pharmacies, and other health-care outlets) and facility ownership (public, private, and informal) are not currently available. In the absence of robust measures of stock-outs in both the public and private sectors across countries and over time, the measurement strategy for producing comparable results for this indicator is unclear. Furthermore, what should constitute a core set of relevant essential medicines is likely to vary by location based on its epidemiological profile, and thus work is needed to more precisely define what these core sets of relevant essential medicines should be given known disease burden, risk factor profiles, and health risks across countries. Lastly, the proposed indicator stipulates measurement of not simply access to a core set of essential medicines but also access to affordable medicines. No comprehensive and comparable datasets on the status of essential medicine affordability, in addition to their stocks, presently exist   | Universal access (100%)                   | ..                               |
| Target 3.c: Substantially increase health financing and the recruitment, development, training, and retention of the health workforce in developing countries, especially in least developed countries and small island developing States   | Health worker density (3.c.1)                            | Health worker density per 1000 population, by cadre and summed across cadres  | Yes                       | Three health worker cadres—physicians, nurses and midwives, and pharmacists—currently comprise indicator 3.c.1; they are reported separately and summed across cadres in this study. Cadres are categorised based on International Standard Classification of Occupations 88 codes, against which alternative or earlier classification schemes and codes are systematically mapped to produce comparable and consistent measures of cadres over time and across locations   | Undefined                                 | ..                               |

(Table 1 continues on next page)

|  | Health-related SDG indicator                | Indicator definition   | Currently measured by GBD | Further details  | SDG target  | SDG target used in this analysis |
|--|---|--|---------------------------|--|---|----------------------------------|
| (Continued from previous page)   |   |  |                           |  |   |                                  |
| Target 3.d: Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction, and management of national and global health risks  | IHR capacity (3.d.1)                        | The WHO-recommended measure of IHR capacity and health emergency preparedness is the percentage of 13 core capacities that have been attained at a specific time (IHR core capacity index). The 13 core capacities are: national legislation, policy, and financing; coordination and national focal point communications; surveillance; response; preparedness; risk communication; human resources; laboratory; points of entry; zoonotic events; food safety; chemical events; and radionuclear emergencies | No                        | Comprehensive and comparable data for all components of the IHR core capacity index, for all locations and over time, are not currently openly available. Self-evaluations have been undertaken by some member states, with a subset followed up with independent assessments via the Joint External Evaluation process. To date, 23 countries have completed this process and made reports fully available out of a total of 43 completed Joint External Evaluations. An additional 30 countries are scheduled for assessment by the end of 2018. As these data become more openly available it might be possible to model regional and temporal trends to obtain estimates for outstanding countries, but this will likely necessitate creating bespoke covariates relating to policy status and types of surveillance system that are not currently reported in the GBD study | Undefined   | ..                               |
| <b>Goal 5: Achieve gender equality and empower all women and girls</b>   |   |  |                           |  |   |                                  |
| Target 5.2: Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation  | Intimate partner violence (5.2.1)           | Age-standardised prevalence of ever-partnered women aged 15 years and older who experienced physical or sexual violence by a current or former intimate partner in the past 12 months, %   | Yes                       | Data on exposure to subtypes of violence are not systematically available across locations and over time; we thus report physical or sexual violence by a current or former intimate partner   | Eliminate by 2030   | ≤0.5%                            |
| Target 5.2 (as above)  | Non-intimate partner violence (5.2.2)       | Age-standardised prevalence of women aged 15 years and older who experienced physical or sexual violence by a non-intimate partner in the past 12 months, %  | Yes                       | Data on exposure to subtypes of violence are not systematically available across locations and over time; we thus report physical or sexual violence by a non-intimate partner   | Eliminate by 2030   | ≤0.5%                            |
| Target 5.6: Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences | Female informed reproductive health (5.6.1) | Proportion of women aged 15–49 years who make their own informed decisions regarding sexual relations, contraceptive use, and reproductive health care, %  | No                        | The proportion of women who make their own informed decisions regarding all three dimensions of this indicator—sexual relations, contraceptive use, and reproductive health care—are included in the Demographic and Health Survey series. Data availability for non-Demographic and Health Survey countries is unclear. The feasibility of measuring this indicator as part of future iterations of the GBD study is being considered   | Universal access (100%)   | ..                               |
| Target 5.6 (as above)  | Reproductive health equal access (5.6.2)    | Number of countries with laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information, and education   | No                        | Across all locations and over time, comprehensive and comparable data documenting the status of laws and regulations regarding access to sexual and reproductive health care, information, and education currently do not exist. Compiling the past and current status of such laws and regulations might be possible; however, systematically assessing their depth or intensity, enforcement, and effectiveness in guaranteeing access to reproductive health care, information, and education might be challenging across locations and over time   | Universal access (100%)   | ..                               |
| <b>Goal 6: Ensure availability and sustainable management of water and sanitation for all</b>  |   |  |                           |  |   |                                  |
| Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all  | Water (6.1.1)                               | Risk-weighted prevalence of populations using unsafe or unimproved water sources, as measured by the SEV for unsafe water, %   | Yes                       | Different types of unsafe water sources have correspondingly different relative risks associated with poor health outcomes; we thus report on the SEV for water, which captures the relative risk of different types of unsafe water sources and then combines them into a risk-weighted prevalence on a scale of 0% (no risk in the population) to 100% (the entire population experiences maximum risk associated with unsafe water)   | Universal access to safe water (100%); 0% on the SEV for unsafe water | ≤1%                              |

(Table 1 continues on next page)

|   | Health-related SDG indicator                                     | Indicator definition  | Currently measured by GBD | Further details   | SDG target   | SDG target used in this analysis |
|---|--|---|---------------------------|---|--|----------------------------------|
| (Continued from previous page)  |  |   |                           |   |  |                                  |
| Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations   | Sanitation (6.2.1a)  | Risk-weighted prevalence of populations using unsafe or unimproved sanitation, as measured by the SEV for unsafe sanitation, %  | Yes                       | We have three mutually exclusive, collectively exhaustive categories for sanitation at the household level: households with piped sanitation (with a sewer connection); households with improved sanitation without sewer connection (pit latrine, ventilated improved latrine, pit latrine with slab, composting toilet), as defined by the Joint Monitoring Programme; and households without improved sanitation (flush toilet that is not piped to sewer or septic tank, pit latrine without a slab or open pit, bucket, hanging toilet or hanging latrine, shared facilities, no facilities), as defined by the Joint Monitoring Programme | Universal access to safe sanitation (100%); 0% on the SEV for unsafe sanitation      | ≤1%                              |
| Target 6.2 (as above)   | Hygiene (6.2.1b)   | Risk-weighted prevalence of populations without access to a handwashing facility, as measured by the SEV for unsafe hygiene, %  | Yes                       | Access to a handwashing facility was defined as having an observed handwashing station with soap and water available in the household   | Universal access to handwashing facility (100%); 0% on the SEV for hygiene           | ≤1%                              |
| Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping, minimising the release of hazardous chemicals and materials, halving the amount of untreated wastewater, and substantially increasing recycling and safe reuse globally  | Treated wastewater (6.3.1)                                       | Proportion of wastewater safely treated, %. UN Water defines this indicator as the proportion of total wastewater generated by both households (sewage and faecal sludge) and economic activities (based on International Standard Industrial Classification categories) that is safely treated. Although the definition conceptually includes wastewater generated from all economic activities, monitoring will focus on wastewater generated from hazardous industries (as defined by relevant International Standard Industrial Classification categories). | No                        | Across all locations and over time, comprehensive and comparable data containing information about total wastewater, as generated by both households and non-household entities (however they are defined), and wastewater treatment status do not currently exist. UN Water suggests that there will be sufficient data to generate estimates of global and regional levels of safely treated wastewater by 2018; however, in the absence of more country-level data, it is difficult to determine the representativeness of such global and regional estimates  | Halve the proportion of untreated wastewater   | ..                               |
| <b>Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all</b>  |  |   |                           |   |  |                                  |
| Target 7.1: By 2030, ensure universal access to affordable, reliable, and modern energy services  | Household air pollution (7.1.2)                                  | Risk-weighted prevalence of household air pollution, as measured by the SEV for household air pollution, %  | Yes                       | Existing datasets do not comprehensively measure population use of clean fuels and technology for heating and lighting across locations; we thus report on the exposure to clean (or unclean) fuels used for cooking  | Universal access to improved fuels (100%); 0% on the SEV for household air pollution | ≤1%                              |
| <b>Goal 8: Promote sustained, inclusive, and sustainable economic growth; full and productive employment; and decent work for all</b>   |  |   |                           |   |  |                                  |
| Target 8.8: Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment   | Occupational risk burden (8.8.1)                                 | Age-standardised all-cause DALY rates attributable to occupational risks, per 100 000 population  | Yes                       | This indicator is reported as DALY rates attributable to occupational risks because DALYs combine measures of mortality and non-fatal outcomes into a single summary measure, and occupational risks represent the full range of safety hazards that might be encountered in working environments   | Undefined  | ..                               |
| <b>Goal 11: Make cities and human settlements inclusive, safe, resilient, and sustainable</b>   |  |   |                           |   |  |                                  |
| Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations | Disaster mortality (11.5.1; same as indicators 1.5.1 and 13.1.1) | Death rate due to exposure to forces of nature, per 100 000 population  | Yes                       | Existing datasets do not comprehensively measure missing people and people affected by natural disasters; we thus report on deaths due to exposure to forces of nature  | Undefined  | ..                               |
| (Table 1 continues on next page)  |  |   |                           |   |  |                                  |

|   | Health-related SDG indicator                                     | Indicator definition   | Currently measured by GBD | Further details  | SDG target                | SDG target used in this analysis |
|---|--|--|---------------------------|--|---------------------------|----------------------------------|
| (Continued from previous page)  |  |  |                           |  |                           |                                  |
| Target 11.6: By 2030, reduce the adverse per-capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management                   | Mean PM <sub>2.5</sub> (11.6.2)                                  | Population-weighted mean levels of fine particulate matter smaller than 2.5 µg in diameter (PM <sub>2.5</sub> ), µg/m <sup>3</sup> | Yes                       | No indicator modifications required  | Undefined                 | ..                               |
| <b>Goal 13: Take urgent action to combat climate change and its impacts</b>   |  |  |                           |  |                           |                                  |
| Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries  | Disaster mortality (13.1.1; same as indicators 1.5.1 and 11.5.1) | Death rate due to exposure to forces of nature, per 100 000 population   | Yes                       | Existing datasets do not comprehensively measure missing people and people affected by natural disasters; we thus report on deaths due to exposure to forces of nature   | Undefined                 | ..                               |
| <b>Goal 16. Promote peaceful and inclusive societies for sustainable development; provide access to justice for all; and build effective, accountable, and inclusive institutions at all levels</b> |  |  |                           |  |                           |                                  |
| Target 16.1: Significantly reduce all forms of violence and related death rates everywhere  | Homicide (16.1.1)  | Age-standardised death rate due to interpersonal violence, per 100 000 population  | Yes                       | No indicator modifications required  | Undefined                 | ..                               |
| Target 16.1 (as above)  | Conflict mortality (16.1.2)                                      | Death rate due to conflict and terrorism, per 100 000 population   | Yes                       | No indicator modifications required  | Undefined                 | ..                               |
| Target 16.1 (as above)  | Physical violence (16.1.3a)                                      | Age-standardised prevalence of physical violence experienced by populations in the past 12 months, %                               | Yes                       | No indicator modifications required  | Undefined                 | ..                               |
| Target 16.1 (as above)  | Psychological violence (16.1.3b)                                 | Age-standardised prevalence of psychological violence experienced by populations in the past 12 months, %                          | No                        | Indicator 16.1.3 involves three separate types of violence experienced by populations: physical, psychological, and sexual. Current data availability allows for reporting of physical and sexual violence as part of the GBD study, whereas substantial challenges remain for the measurement of psychological violence across locations, by sex, and over time. These include issues with self-report and recall periods; non-standard classifications and reporting of types of psychological violence; and overall minimal data availability on psychological violence, particularly among males | Undefined                 | ..                               |
| Target 16.1 (as above)  | Sexual violence (16.1.3c)  | Age-standardised prevalence of sexual violence experienced by populations in the past 12 months, %                                 | Yes                       | No indicator modifications required  | Undefined                 | ..                               |
| Target 16.1 (as above)  | Safety walking alone (16.1.4)                                    | Proportion of people who feel safe walking alone around the area in which they live, %   | No                        | The Gallup World Poll, which is currently active in more than 140 countries, includes questions about reported safety while walking alone near one's residence. Pending data sharing and access to currently available data, this indicator will be included in future iterations of the GBD study   | Undefined                 | ..                               |
| Target 16.2: End abuse, exploitations, trafficking, and all forms of violence against and torture of children   | Child sex abuse (16.2.3)   | Age-standardised prevalence of women and men aged 18–29 years who experienced sexual violence by age 18 years, %                   | Yes                       | No indicator modifications required  | Eliminate by 2030         | ≤0.5%                            |
| Target 16.9: By 2030, provide legal identity for all, including birth registration  | Birth registration (16.9.1; same as indicator 17.19.2b)          | Proportion of children younger than 5 years whose births have been registered with a civil authority, by age, %                    | No                        | Currently, birth registration data reported to WHO do not fully cover all locations or years under analysis, and supplementary data sources, such as household survey data, are often required to estimate births and birth rates outside of high-income regions. Substantive data collation efforts would be required for birth registration by location and over time  | Universal coverage (100%) | ..                               |

(Table 1 continues on next page)

25 years does not.<sup>24</sup> Quintile breaks were generated from the distribution of SDI at the national level in countries with populations greater than 1 million applied to all 195 locations. A complete list of SDI quintiles by location are available in appendix 1.<sup>24</sup>

### Projection of the health-related SDG indicators to 2030

To generate projections to 2030, we used forecasting methods developed by Foreman and colleagues that produced reference forecasts and alternative health scenarios for life expectancy, all-cause mortality, and

|   | Health-related SDG indicator                            | Indicator definition   | Currently measured by GBD | Further details   | SDG target                                | SDG target used in this analysis |
|---|---|--|---------------------------|---|---|----------------------------------|
| (Continued from previous page)  |   |  |                           |   |   |                                  |
| <b>Goal 17: Strengthen the means of implementation and revitalise the global partnership for sustainable development</b>  |   |  |                           |   |   |                                  |
| Target 17.19: By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity building in developing countries | Population census (17.19.2a)                            | Population census status within the past 10 years  | Yes                       | Indicator 17.19.2 involves three separate country-level components pertaining to demographic and health data collection and monitoring: status of conducting at least one population and housing census in the past 10 years, birth registration, and death registration. Although these data collection and monitoring systems are interconnected, their actual status or functionality at a given time can vary. Thus, we have separated reporting on 17.19.2 into three indicators. For indicator 17.19.2a, census status was ascertained according to whether a population and housing census was conducted within the past 10 years for a given location-year or a population registry had been established. Census implementation was cross-checked against the World Population and Housing Census Programme online database | Census conducted within the past 10 years | ..                               |
| Target 17.19 (as above)   | Birth registration (17.19.2b; same as indicator 16.9.1) | Proportion of countries that have achieved 100% birth registration, %                                | No                        | Indicator 17.19.2 involves three separate country-level components pertaining to demographic and health data collection and monitoring: status of conducting at least one population and housing census in the past 10 years, birth registration, and death registration. Currently, birth registration data reported to WHO do not fully cover all locations or years under analysis, and supplementary data sources, such as household survey data, are often required to estimate births and birth rates outside of high-income regions. Substantive data collation efforts would be required for birth registration by location and over time   | Universal coverage (100%)                 | ..                               |
| Target 17.19 (as above)   | Well-certified death registration (17.19.2c)            | Percentage of well-certified deaths by a vital registration system among a country's total deaths, % | Yes                       | Indicator 17.19.2 involves three separate country-level components pertaining to demographic and health data collection and monitoring: status of conducting at least one population and housing census in the past 10 years, birth registration, and death registration. Although these data collection and monitoring systems are interconnected, their actual status or functionality at a given time can vary. Thus, we have separated reporting on 17.19.2 into three indicators. For indicator 17.19.2c, well-certified deaths were determined by three measures: completeness of death registration, fraction of deaths not assigned to major garbage codes (ie, causes that cannot or should not be underlying causes of death), and fraction of deaths assigned to detailed GBD causes                                     | 80% of total deaths                       | ≥80%                             |

Detailed descriptions of the data and methods used to estimate each of the 41 health-related SDG indicators included in the GBD 2017 study are located in appendix 1. For the 11 indicators currently not measured by GBD, additional information about data and measurement needs are provided in this table. DALY=disability-adjusted life-year. DPT=diphtheria-pertussis-tetanus. GBD=Global Burden of Diseases, Injuries, and Risk Factors Study. IHR=International Health Regulations. IOTF=International Obesity Task Force. NCDs=non-communicable diseases. PM<sub>2.5</sub>=fine particulate matter smaller than 2.5 µm. SDG=Sustainable Development Goal. SEV=summary exposure value. TRIPS=World Trade Organization Agreement on Trade-Related Aspects of Intellectual Property Rights. UHC=universal health coverage. WaSH=water, sanitation, and hygiene.

Table 1: Health-related goals, targets, and SDG indicators

cause-specific mortality.<sup>36</sup> The modelling framework was designed to account for the relationships between risk factors and other independent drivers of health outcomes (eg, gains in sociodemographic development, select interventions such as vaccine coverage, and met need for family planning), thus better capturing causal pathways of health change shown in randomised controlled trials and cohort studies.

We generated projections for independent drivers by calculating the annual change in each location and year from 1990 to 2017 in logit or natural-log space, and then computing weighted annualised rates of change. If weights were closer to zero, annual rates of change over time were more equally weighted across years; if weights were closer to higher values, recent years were more

heavily weighted than were earlier years. These weights were selected through out-of-sample predictive validity tests; further details on the overarching forecasting framework and weight selection are in appendix 1 (part 3). Some causes (eg, natural disasters, conflict and terrorism, and HIV) required model modifications or alternative estimation strategies to account for either their stochastic nature or, in the case of HIV, unique sensitivity to intervention coverage (see appendix 1 part 3, and elsewhere<sup>36</sup>).

Some indicators were inputs or outputs of the forecasting platform; for others, we used the weighted annualised rate of change method to produce projections to 2030 (appendix 1 part 3). For the UHC service coverage index, a modified version of the overarching forecasting

framework was used, modelling the relationship between total health spending per capita and the UHC service coverage index with stochastic frontier analysis.<sup>37</sup> We did not generate projections of census coverage because of its binary nature and the lack of documentation about planned censuses across all countries. Additionally, we do not currently project indicators by sex or subnationally.

### Health-related SDG index

The health-related SDG index was originally developed in GBD 2015.<sup>13</sup> The overall index for GBD 2017 consisted of 40 health-related SDG indicators (population census coverage was not included because of its binary status and because it does not have forecasts). To create the health-related SDG index, we used a preference-weighted approach in which we considered the SDGs as representing the expressed preferences of UN member states and thus assumed that each SDG target should be weighted equally.

Each indicator was scaled to a value from 0 to 100, reflecting worst to best performance, to enable optimal comparison across diverse indicators, with 0 being the 2·5th percentile value and 100 being the 97·5th percentile value of 1000 observed or projected draws over the period 1990–2030. This approach reduced sensitivity to extreme outliers in given location-years. Negative indicators, for which lower values were more desirable than higher values (ie, mortality, incidence or prevalence, and risk exposure), were assigned 100 for the 2·5th percentile and 0 for the 97·5th percentile. For mortality and incidence, values were scaled in log-space.

We calculated the geometric mean of scaled health-related SDG indicators by target, and then took the geometric mean across all health-related SDG targets to produce the overall health-related SDG index. We used the geometric mean to allow for partial substitutability (ie, permitting high values for some indicators to only partially compensate for indicators with very low values). We restricted indicators to a minimum value of 1 when calculating the overall index to mitigate issues with values close to 0. To generate subnational SDG indices, we used the national-level 2·5th and 97·5th percentile values for each indicator to scale indicators for each subnational location. We used the same overall index construction methods for national and subnational locations.

For health worker density (SDG indicator 3.c.1), we used a modified scaling approach to reflect the importance of each health worker cadre (physicians, nurses and midwives, and pharmacists). On the basis of logistic regressions between each cadre and the HAQ Index,<sup>34</sup> we identified the values at which additional increases in health worker density resulted in diminishing returns on the HAQ Index.<sup>34</sup> In per 10000 population space, these threshold values were 30 physicians, 100 nurses and midwives, and five pharmacists (appendix 1 part 1). Although we used the 2·5th percentile value of

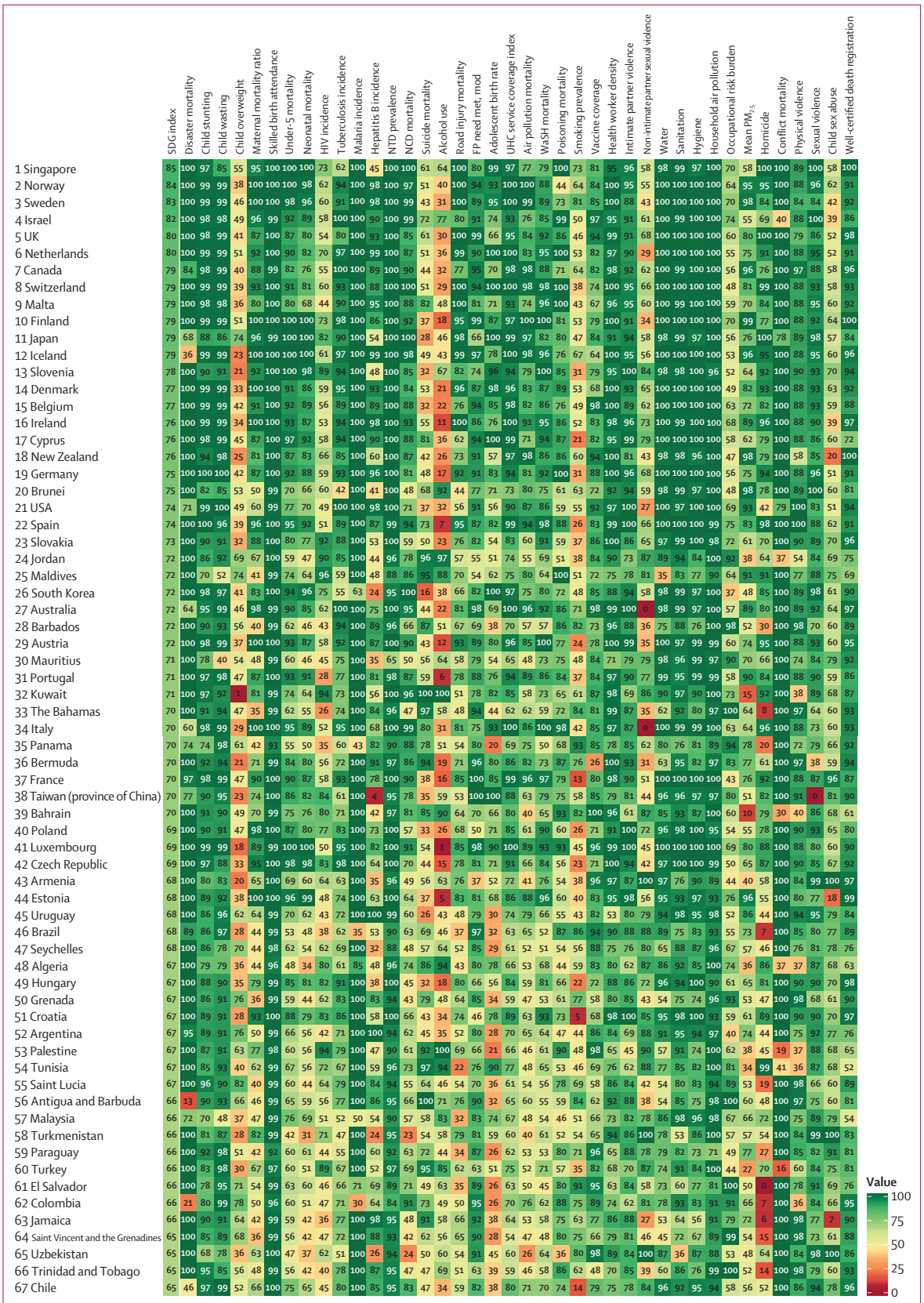
1000 draws observed or projected from 1990 to 2030 to set the 0 threshold for all three cadres of health workers, we used cadre-specific thresholds to set the bounds for a 100 score rather than the 97·5th percentile of 1000 draws. We then took the geometric mean of scaled scores across the three cadres to estimate overall performance on the health worker density indicator.

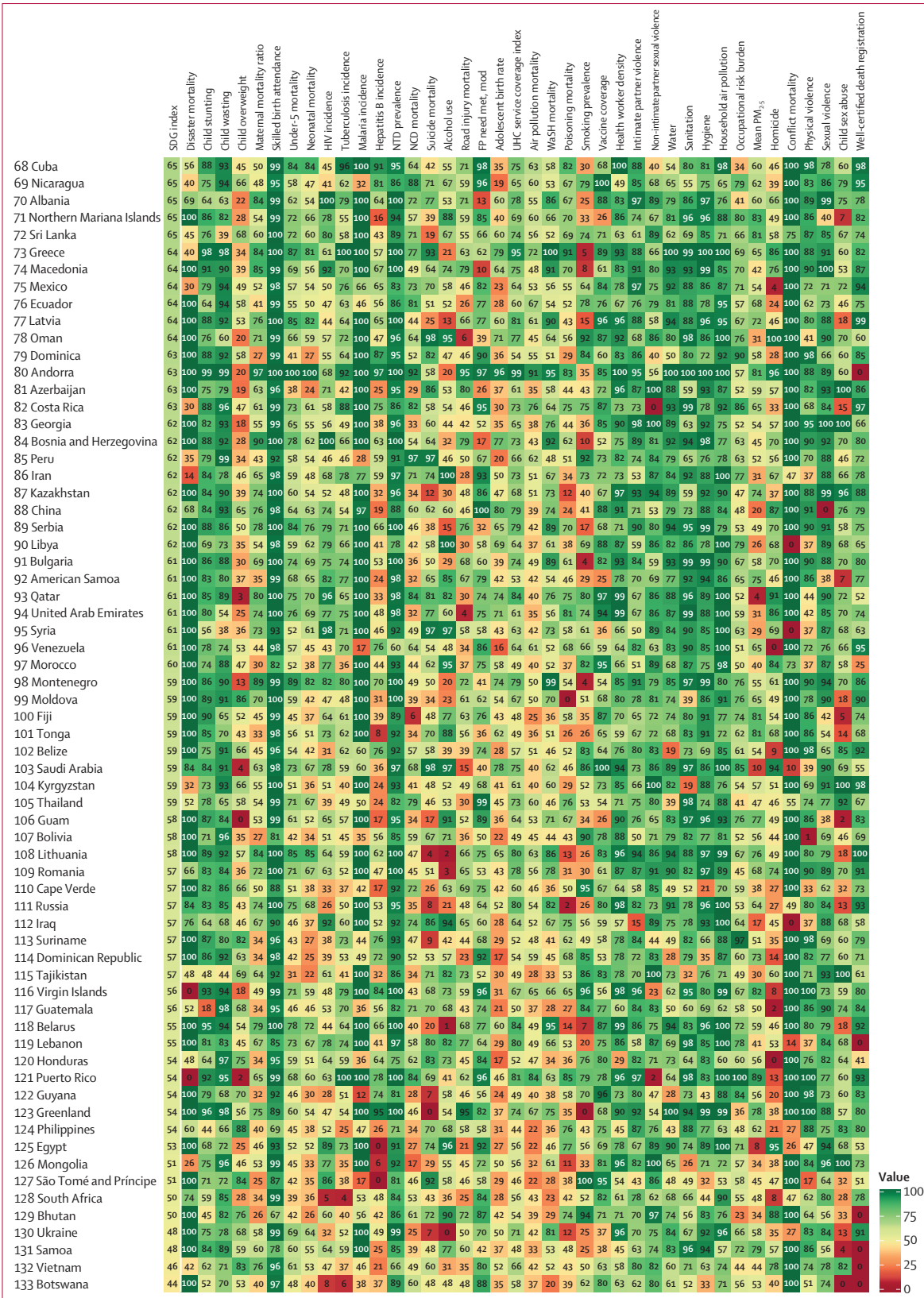
### Country and global SDG indicator attainment

Some health-related SDG indicators have targets explicitly defined by UN resolution 71/313,<sup>38</sup> including absolute targets and targets set in relation to 2015 values, whereas some indicators have undefined targets. In this analysis, 25 indicators had defined targets, for which we applied corresponding thresholds to analyse 2030 attainment (2020 in the case of road injury mortality, as set by the UN). For indicators with targets related to universal coverage or access, we set thresholds as 99%, whereas for indicators with targets related to achieving elimination or ending epidemics, we set thresholds as an incidence of 0·5 per 100000 population or less or a prevalence of 0·5% or less. Thresholds or relative reductions for each target are shown in table 1.

For GBD 2017, we estimated the probability of each country attaining health-related SDG indicators with defined targets. We used our indicator projections to 2030 at the draw level (1000 draws in total), calculating at each draw whether or not a country would attain a target. The total probability of attainment was the number of draws in which the country would attain the target divided by the total number of draws. We also calculated the mean estimate in 2030 (the average of 1000 draws), and used that estimate to assess whether or not a country would attain a target. Consequently, countries could have some probability of attainment for given targets despite not having projected attainment at the mean level.

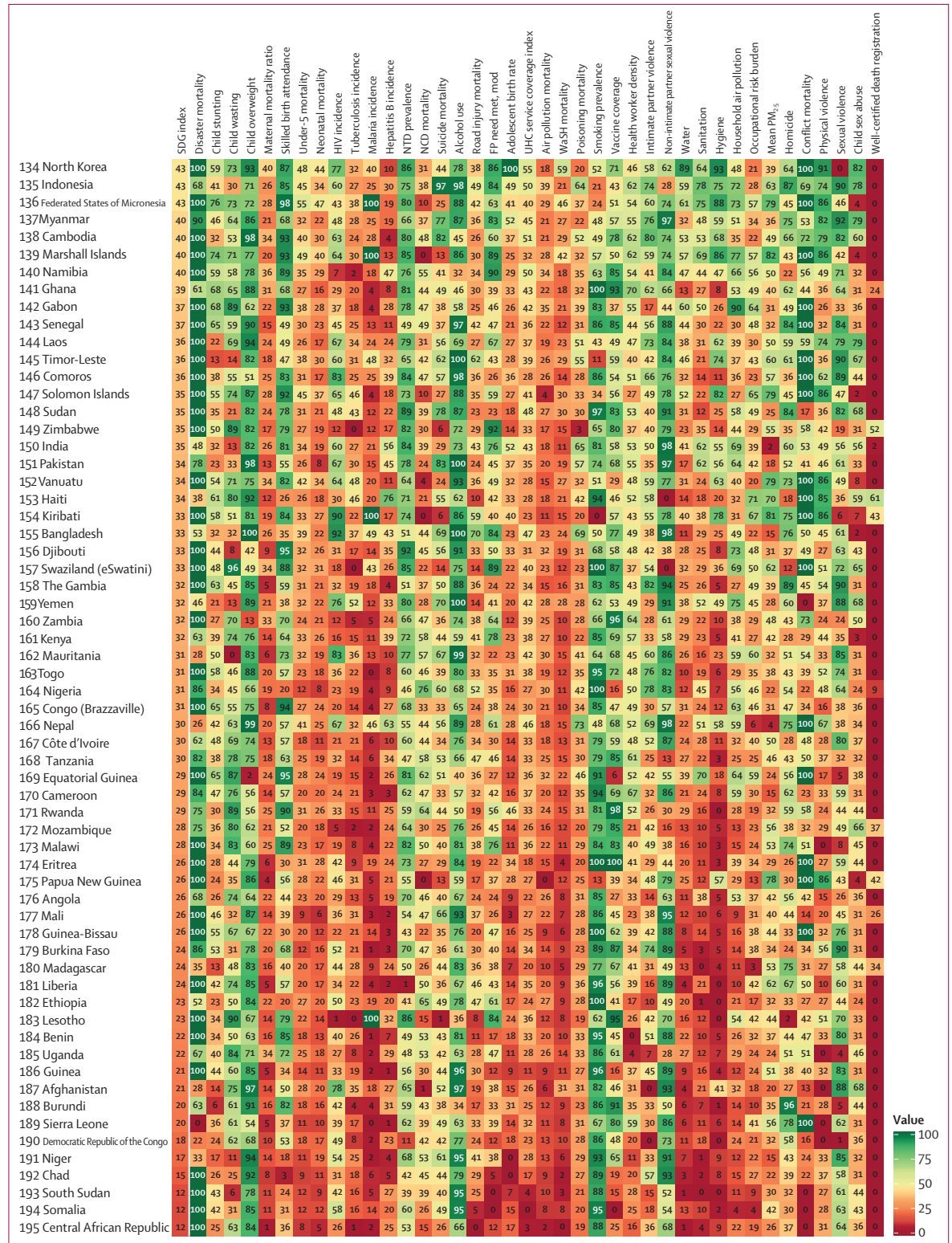
We also used past rates of change observed before the SDG era (ie, 1990–2015, or the monitoring period of the Millennium Development Goals) to analyse the feasibility of attaining SDG indicator targets in 2030. For SDG indicators with defined targets, we compared country-level annualised rates of change for 1990–2015 (ie, what has been achieved in the past) with the global pace of progress required to meet targets during the SDG era (2015–30) based on 2015 global estimates for each indicator; these estimates were derived from population-weighted means. For each indicator, we compared the required global annualised rate of change for 2015–30 against the distribution of past country-level annualised rates of change, and calculated in which percentile of performance the global required annualised rate of change would fall. We took the mean of those percentiles across the 25 indicators with defined targets and found that, on average, the required global annualised rates of change for 2015–30 would be in the 90th percentile of performance compared with the





country-level annualised rates of change for 1990–2015. To see what global progress could be achieved if performance on all indicators was projected at that level

from 2015 to 2030, we calculated the annualised rate of change required to meet the 90th percentile for each indicator, including those without defined targets, and



projected the 2030 value and corresponding percentage change from 2015 to 2030 based on these annualised rates of change.

### Uncertainty analysis

For all indicator estimates, GBD 2017 produced 1000 draws by location, age, and sex and for all years. Draws from the posterior distribution represent uncertainty in steps in the estimation process as well as in underlying data sources. For each scaled SDG indicator and the health-related SDG index, we calculated 95% uncertainty intervals (UIs) on the basis of these 1000 draws using simulation analysis. Further information about GBD uncertainty analysis is provided in related GBD publications.<sup>21,23–27</sup>

### Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

## Results

### Health-related SDGs in 2017

The global median health-related SDG index was 59·4 (IQR 35·4–67·3) in 2017, ranging from a low of 11·6 (95% UI 9·6–14·0) to a high of 84·9 (83·1–86·7; figure 1). The overall health-related SDG index masked substantial variation across indicators within countries. Many countries with low overall index scores performed reasonably well on some individual indicators and vice versa. For example, although Kenya scored only 31·7 (30·6–32·9) on the overall health-related SDG index for 2017, the country scored much better on met need for family planning (77·8, 74·6–80·9) and smoking prevalence (85·4, 82·6–88·0). By contrast, South Korea, which scored 72·2 (69·0–74·4) on the overall index, scored comparatively worse on suicide mortality (16·3, 11·5–21·1). Results for each indicator and country can be explored through the online data visualisation tool.

Scores for NCD mortality were worst in Afghanistan and in many countries in Oceania; the best scores were primarily among higher-SDI countries, with the

exception of Peru (figure 1). Most countries with the best alcohol use scores were in north Africa and the Middle East, whereas countries with the worst values were generally concentrated in Europe. The worst smoking prevalence scores were found among a heterogeneous set of locations (eg, Greenland, Kiribati, and Montenegro), and the best were primarily found in sub-Saharan Africa. Suicide mortality scores were generally best in countries in the Middle East and worst in a variety of countries (eg, Greenland, Lesotho, and Lithuania).

The worst scores for health worker density were primarily in sub-Saharan African countries; by contrast, Cuba, Qatar, and many European countries recorded among the best scores for this indicator. Several Latin American countries had the worst scores for sexual violence by non-intimate partners, whereas several countries in central Asia, eastern Europe, and south Asia had the best scores for this indicator.

During 2008–17, 165 countries conducted at least one population and housing census. 30 countries had existing or had implemented population registries during this time, and eight of these countries had conducted at least one census since 2008 (appendix 2). Eight countries did not have this important source of demographic information over the full time period.

### Global and subnational variation

Performance on the health-related SDG index in 2017 varied globally (figure 2) and at the subnational level (figure 3). Countries in the tenth decile of performance—those with the best index values—were primarily in western Europe, although Canada, Japan, and Singapore were also in this decile. Afghanistan was in the first decile of performance, which otherwise predominantly included countries in sub-Saharan Africa.

Among the countries with subnational SDG index scores (figure 3), India (which ranked in the third decile nationally) had the largest range in 2017, with a 34·9-point difference between states with the highest and lowest scores. China also had considerable subnational differences, performing in the sixth decile nationally but recording a 19·3-point difference in scores across provinces, followed by the USA (ninth decile nationally and a 14·8-point difference across states) and Mexico (seventh decile nationally and a 15·3-point difference across states). Scores were most homogeneous in Japan (tenth decile nationally and a 3·0-point difference across subnational locations), the UK (tenth decile nationally and a 3·6-point difference across regions in England), and Brazil (eighth decile nationally and an 8·0-point difference across states).

### Variation by sex and SDI

Globally, the median age-standardised NCD mortality rate, as it aligns with the UN definition, was higher for males (472·0 [IQR 330·5–604·9] per 100 000) than for

For the online data visualisation tool see <https://vizhub.healthdata.org/sdg>

#### Figure 1: Performance on the health-related SDG index and 40 individual health-related indicators, by location, in 2017

Countries and territories are ranked by their health-related SDG index from highest to lowest in 2017. Indices and individual indicators are reported on a scale of 0 to 100, with 0 representing the worst scores from 1990 to 2030 and 100 reflecting the best during that time. SDG indicator 17.19.2a, population census status within the past 10 years, was not included in the health-related SDG index because projections were not generated for this indicator. Definitions of health-related SDG indicators are shown in table 1. FP=need met, mod=family planning need met with modern contraception methods. NCD=non-communicable disease. NTD=neglected tropical disease. PM<sub>2.5</sub>=fine particulate matter smaller than 2.5 µm. SDG=Sustainable Development Goal. UHC=universal health coverage. WaSH=water, sanitation, and hygiene.

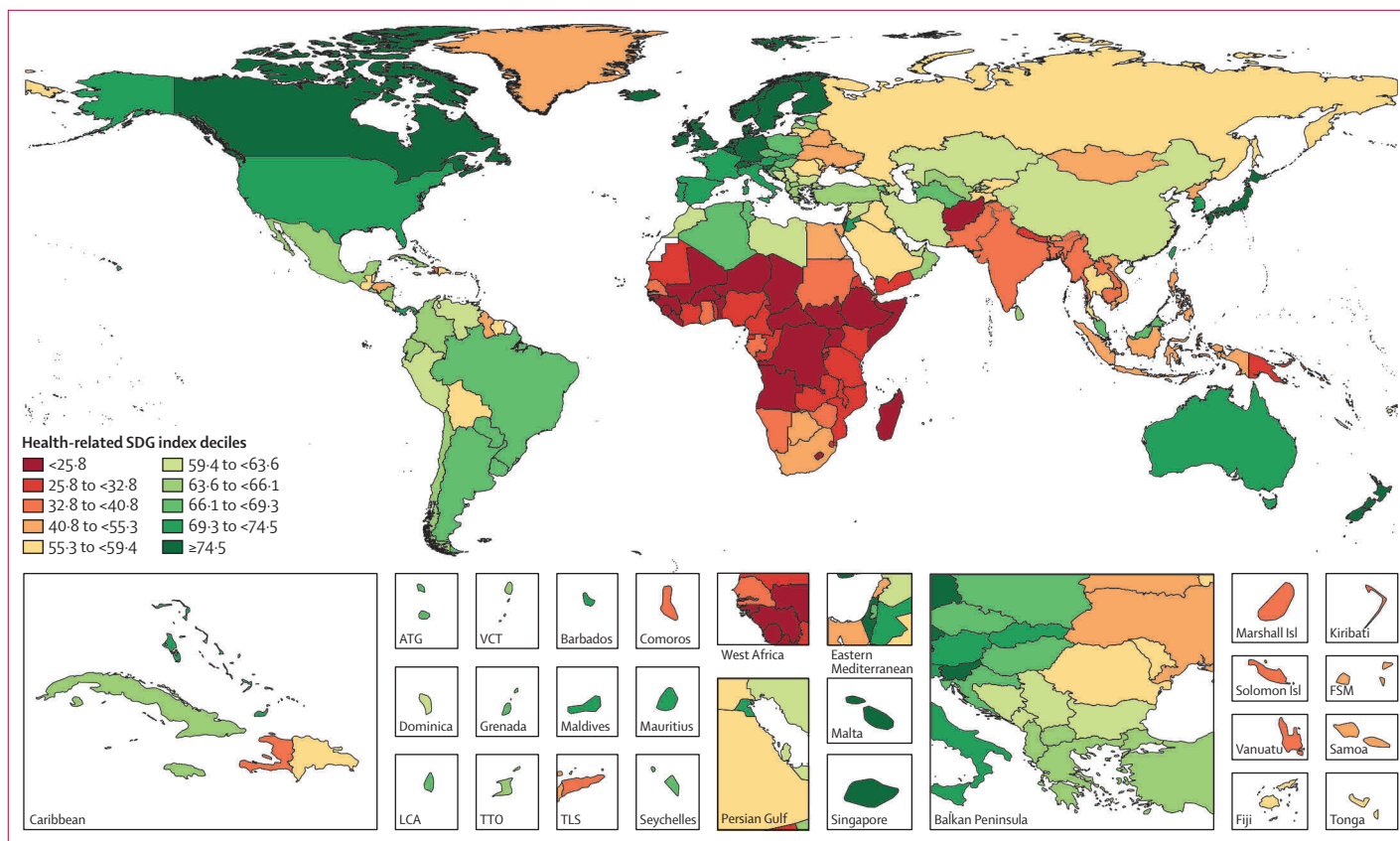


Figure 2: Health-related SDG index by decile, 2017

Deciles are based on the distribution of health-related SDG indices for countries and territories in 2017. ATG=Antigua and Barbuda. FSM=Federated States of Micronesia. Isl=Islands. LCA=Saint Lucia. SDG=Sustainable Development Goal. TLS=Timor-Leste. TTO=Trinidad and Tobago. VCT=Saint Vincent and the Grenadines.

females (307.8 [215.4–417.9] per 100 000; figure 4). Variation by sex was also pronounced for alcohol use (18.5% [IQR 8.4–27.3] of males vs 6.4% [2.2–11.8] of females), smoking prevalence (25.0% [IQR 17.2–34.7] of males vs 6.1% [3.0–15.8] of females), and suicide mortality (13.8 [IQR 8.8–19.7] per 100 000 males vs 4.0 [2.5–5.6] per 100 000 females; figure 4).

NCD mortality showed an inverse association with SDI quintile, with the lowest mortality in high-SDI countries. Males in high-middle-SDI countries were the exception, recording higher mortality rates than males in middle-SDI and low-middle-SDI countries. Disparities in NCD mortality by sex emerged across SDI quintiles, particularly among high-middle-SDI countries, for which the median age-standardised mortality rate was 512.4 (IQR 356.2–643.9) per 100 000 males and 285.9 (250.1–333.6) per 100 000 females. Alcohol use was generally higher among higher-SDI quintiles, although differences between sexes were smallest in low-SDI and low-middle-SDI countries. Smoking prevalence was also higher among higher-SDI quintiles, with the exception of males in high-SDI countries who had a lower smoking prevalence than males in high-middle-SDI

countries. Differences between sexes were pronounced across SDI quintiles but were often smallest in high-SDI countries. The median age-standardised suicide mortality rate showed a U-shaped pattern, with the highest rates in high-SDI and low-SDI countries.

Overall, males had worse health outcomes—higher mortality, incidence, and risk exposure—than females for all ten disaggregated indicators globally and across SDI quintiles; the primary exception was HIV incidence among low-SDI countries, where the incidence was higher in females than in males (figure 4). In 2017, the global median age-standardised incidence of HIV was 0.14 (IQR 0.04–0.37) per 1000 males versus 0.07 (0.02–0.30) per 1000 females. For tuberculosis, the global median age-standardised incidence was 48.9 (IQR 18.6–211.2) per 100 000 males and 39.7 (14.8–187.0) per 100 000 females. Overall, age-standardised mortality rates for road injuries and poisoning were lower among higher-SDI countries. In 2017, the global median mortality rate from road injuries was 21.5 (IQR 12.9–32.5) per 100 000 males and 7.0 (4.0–12.1) per 100 000 females, while the equivalent for poisoning mortality was 0.8 (0.4–1.7) per 100 000 males and 0.4 (0.2–0.8) per 100 000 females.

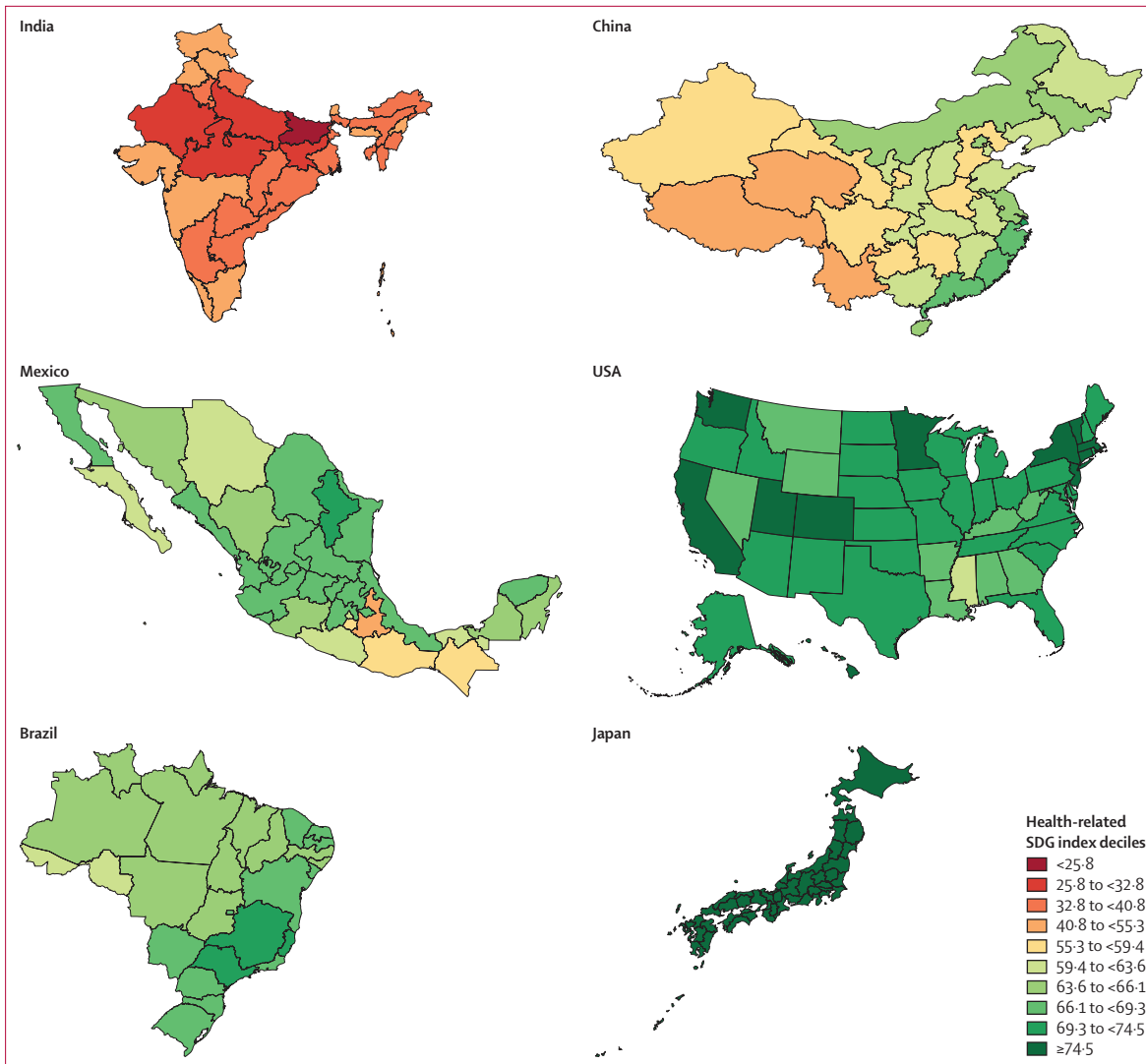


Figure 3: Health-related SDG index for selected subnational locations, 2017

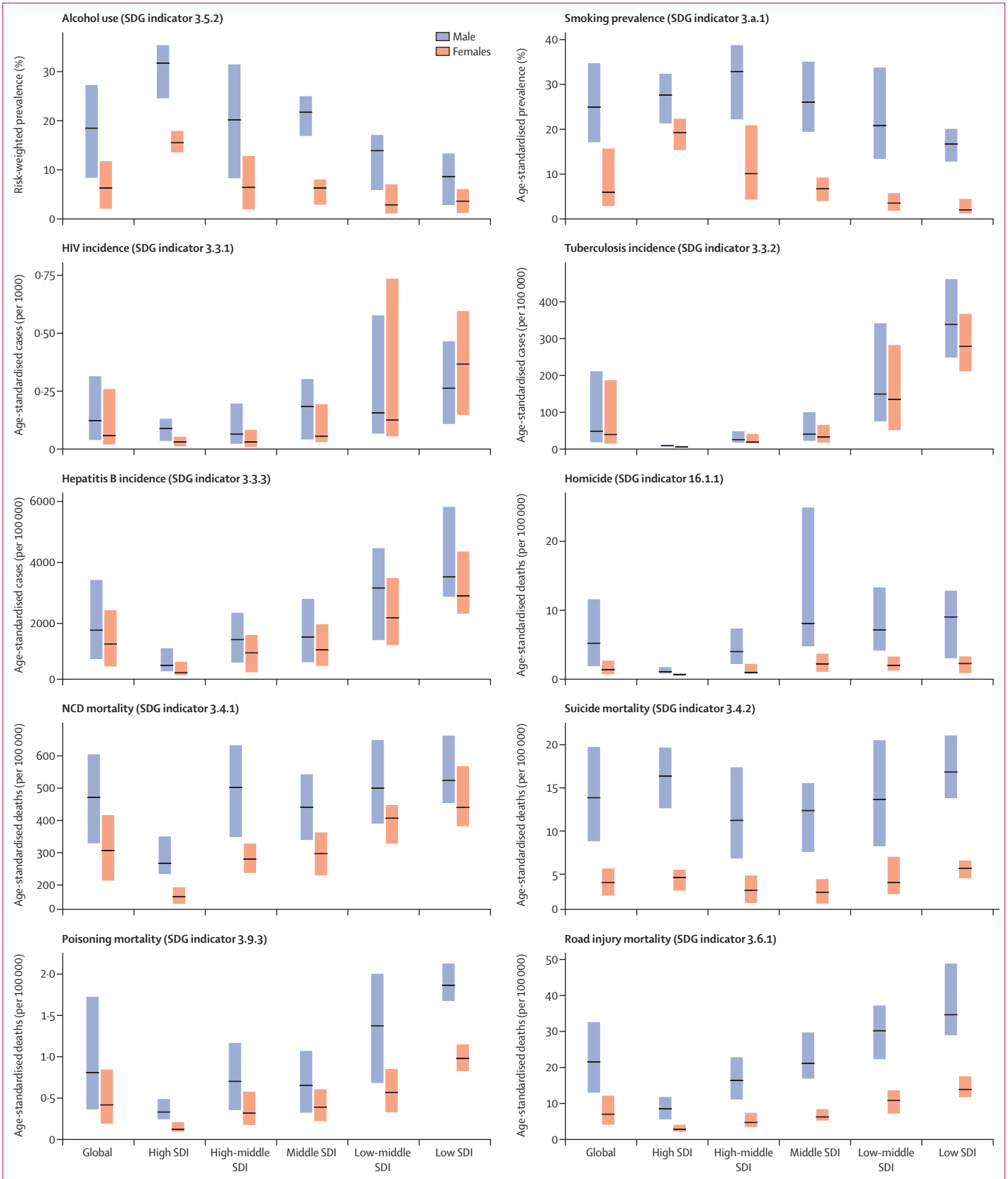
Deciles are based on the distribution of health-related SDG indices for countries and territories in 2017, and then applied for subnational locations. SDG=Sustainable Development Goal.

### Health-related SDGs in 2030 and target attainment

On the basis of past trends, most countries were projected to have higher health-related indices in 2030 than in 2017 (appendix 2). For the health-related SDG indicators with defined targets (figure 5; appendix 2), the probability of attainment by 2030 varied substantially across locations and by indicator. Under-5 mortality, neonatal mortality, maternal mortality ratio, and malaria had at least 100 countries or territories with at least a 95% probability of attaining defined targets in 2030. Indicators including vaccine coverage, HIV incidence, neglected tropical diseases prevalence, non-intimate partner violence, well-certified death registration, and environmental risks such as sanitation and household air pollution showed substantial heterogeneity in terms of projected attainment, with many

locations recording probabilities of less than 10% and others recording probabilities of 95% or higher. For nine indicators, including child overweight, road injury mortality, and tuberculosis, all 195 countries and territories had lower than 5% probability of attainment by 2030.

Figure 6 shows the distribution of annualised rates of change in 195 locations for 1990–2015. For several indicators, the global required annualised rates of change were met or exceeded by many countries not in the top decile of performance from 1990 to 2015. These indicators generally had value-specific SDG targets, such as under-5 mortality (ie,  $\leq 25$  deaths per 1000 livebirths), or had targets linked to universal access or coverage of specific interventions (ie, vaccine coverage and met need for family planning). Furthermore, most of these indicators



had origins in the Millennium Development Goals era. Despite substantial progress in the past, only countries in the top decile of performance for 1990–2015 met or surpassed the global rate of change required to meet the maternal mortality ratio target for 2030 (ie, <70 deaths per 100 000 livebirths), and very few countries recorded the rates of change required at the global level to meet the UHC service coverage target by 2030. A similar pattern emerged for NCD mortality. For other health-related SDG indicators, the global annualised rates of change required to meet their SDG targets far exceeded the pace of progress ever recorded by any country in the past (figure 6). These included several elimination indicators for infectious diseases, such as HIV and tuberculosis, and environmental risks such as household air pollution, among others (figure 6; appendix 1).

For NCD mortality and suicide mortality, performance at the global mean percentile of past rates of change (90th percentile) aligned with defined SDG targets of reducing rates by a third from 2015 to 2030 (ie, the equivalent of a 32·5% reduction for NCD mortality and a 31·4% reduction for suicide mortality; table 2). Yet, for several indicators, performance at the 90th percentile would not equate to meeting established SDG targets. Many indicators with elimination targets saw the widest gaps in how the 90th percentile could translate into global attainment in the SDG era. For example, indicators under SDG target 2.2, which aims to end all forms of malnutrition, would see the global average for child stunting decrease to 18·0% and wasting to 5·0% in 2030 if the 90th percentiles of past rates of change are achieved. For child overweight, the 90th percentile equated to a 0·5% decrease by 2030, from a global average of 15·9% in 2015 to 15·8% in 2030. SDG target 3.3 calls for ending the epidemics of several infectious diseases, including tuberculosis, HIV, and neglected tropical diseases; based on the 90th global mean percentile, the global percentage change from 2015 to 2030 would fall short of such aspirations for most of these causes (ie, decrease of 7·9% for hepatitis B, 35·6% for tuberculosis, 53·4% for HIV, and 48·2% for neglected tropical diseases). The exception was malaria, which would decrease by 94·0% at the 90th percentile.

For two leading risk factors, alcohol use (SDG indicator 3.5.2) and prevalence of current smoking (SDG indicator 3.a.1), annualised rates of change in the 90th percentile would equate with 18·7% and 21·9% reductions, respectively, at the global level from 2015 to 2030 (table 2). Global percentage declines would range from 41·5% for mortality attributable to ambient air

pollution and household air pollution (SDG indicator 3.9.1) to 68·1% for mortality attributable to unsafe water, sanitation, and hygiene (SDG indicator 3.9.2), reflecting the substantive improvements in reducing mortality attributable to these risks that many countries achieved in 1990–2015. If the 90th percentile was used as an SDG target, adolescent birth rates would need to decrease by 47·4%, or to a global average of 11·4 per 1000 females aged 10–19 years in 2030, and health worker density would need to increase by 85·4%, from an average of 5·9 per 1000 population in 2015 to 10·9 per 1000 population in 2030.

## Discussion

### Summary of findings

Although nearly all countries were projected to have improved health-related SDG index scores by 2030, progress varied by country and across individual indicators. Performance on health-related SDG indicators differed subnationally for several countries, as well as by sex and across SDI quintiles, highlighting the need for disaggregated data to ensure that no one is left behind. For many indicators, the annualised rate of change required to meet defined targets far exceeded the pace of progress achieved by any country in the recent past. Yet, even for those indicators with a mean projected value that fell short of the 2030 target, there was some probability of attainment by 2030, highlighting the potential for future SDG achievements if progress can be accelerated in the coming years. These results highlight the need for more rapid yet strategic implementation of programmes and continued monitoring of inequalities in the health-related SDGs within populations.

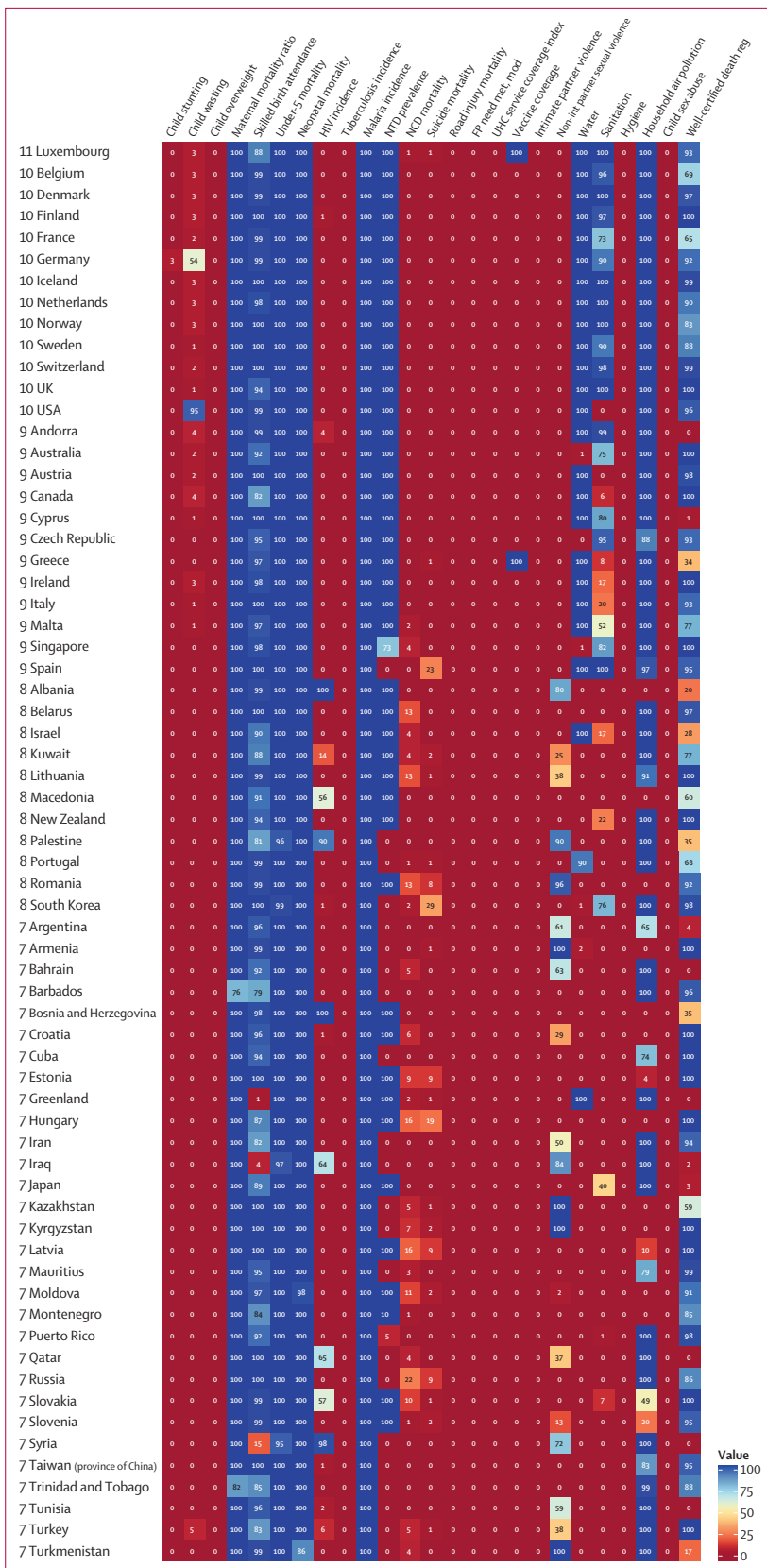
### SDG indicator progress and challenges

Health-related SDG index scores were projected to be higher in 2030 than in 2017 in almost all countries; however, improved index performance does not inherently reflect whether or not countries will attain individual SDG targets. The composite nature of the index means that many factors have a part in determining a country's overall score, and ensuring that progress on the index score translates into progress across indicators and equitably across populations will continue to be a challenge for countries.

Countries that performed well on the health-related SDG index commonly scored worse on the individual indicators of childhood overweight and alcohol use than on other indicators. Among countries that performed worst on the health-related SDG index, well-certified death registration was a frequent challenge. As populations age, all countries will need to strengthen health information systems to ensure death registration keeps pace with increasing mortality in older populations.<sup>23</sup> Although suicide mortality and alcohol use prevalence appeared to be lowest in many countries in north Africa and the Middle East, in places where these practices are

**Figure 4: Median values for select SDG indicators, by sex, at the global level and by SDI quintile, 2017**

The lengths of the coloured rectangles represent the IQRs. More detail on the SDG indicators included in this figure can be found in table 1. SDG=Sustainable Development Goal. SDI=Socio-demographic Index.



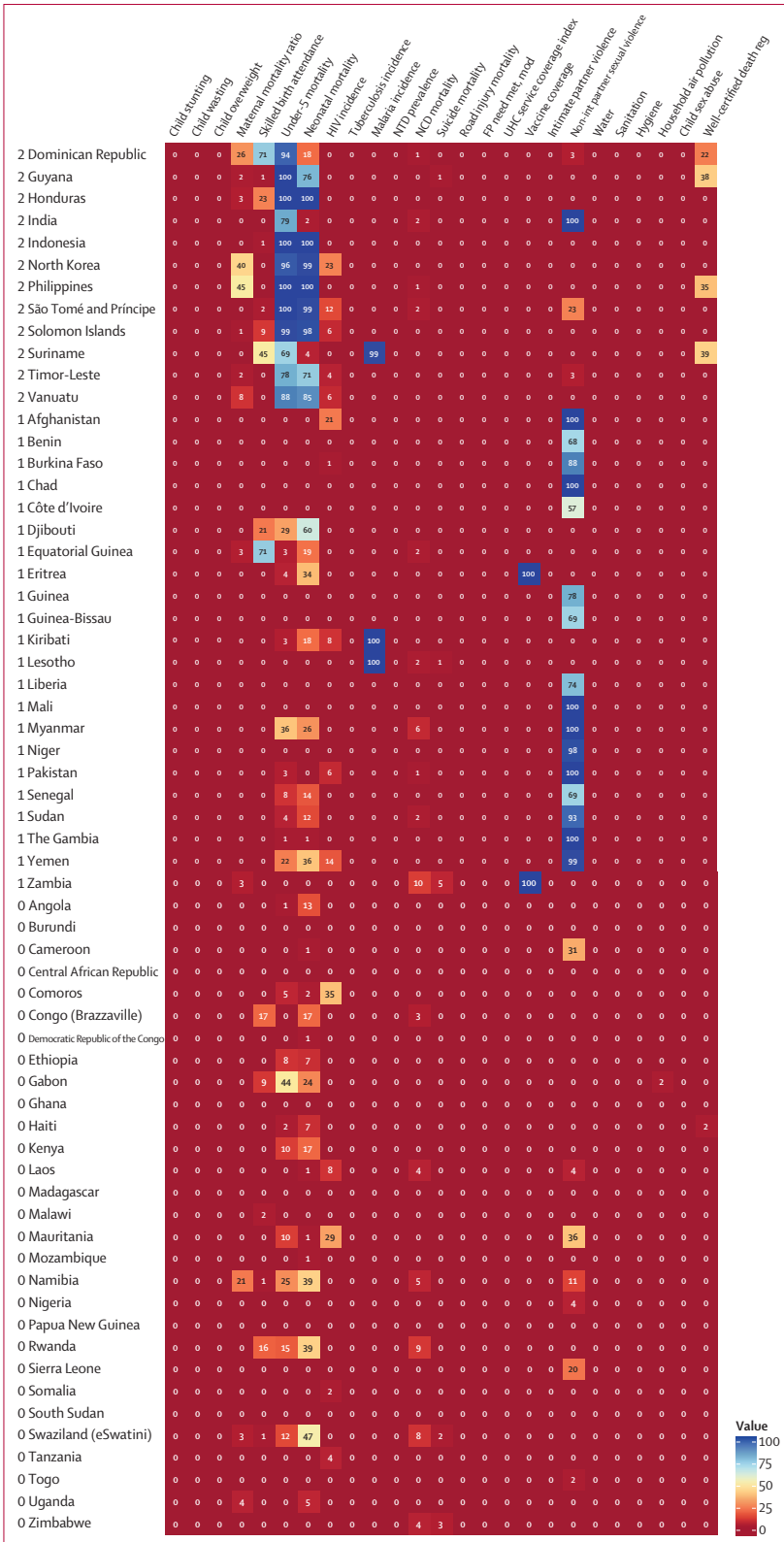
(Figure 5 continues on next page)

deemed illegal or shameful, our results might reflect a death of accurate data rather than true circumstances.<sup>39,40</sup>

Without a concerted scale-up of efforts to prevent and treat NCDs, most countries will fall short of the 2030 SDG target.<sup>9</sup> The NCDs included in SDG indicator 3.4.1—cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases—accounted for 82.8% of all deaths due to NCDs in 2017.<sup>21</sup> Total deaths due to NCDs increased from 9.5 million in the population aged 30–69 years in 1990 to 12.9 million in 2017 (or 62.9% of all deaths in that age group).<sup>23</sup> Of those 12.9 million deaths, 6.3 million were due to cardiovascular diseases, 4.9 million to cancers, 1.1 million to chronic respiratory diseases, and 0.6 million to diabetes.<sup>23</sup> Although the absolute number of deaths due to NCDs is rising annually, in most countries, this increase is the result of population ageing and growth; with the exception of diabetes, age-standardised NCD mortality rates for NCDs included in the SDG indicator have generally decreased.<sup>23</sup> Nonetheless, many NCD-related risk exposures have seen minimal changes over time or are increasing, portending future challenges if more deliberate action is not taken against NCDs.<sup>21</sup>

In many countries, reductions in mortality due to cardiovascular diseases have been driven by improved access to antihypertensives and statins for addressing high cholesterol.<sup>41,42</sup> Investing in programmes that promote the early diagnosis and control of such metabolic risks should be prioritised by national governments and development partners.<sup>43</sup> Furthermore, prevention of other modifiable risk factors, such as smoking,





similar patterns by sex: on average, males were more likely than females to smoke and consume harmful levels of alcohol, and while use was often higher among people living in higher-SDI countries, sex differences in these countries were also more pronounced.<sup>60,61</sup> Although the global smoking prevalence decreased from 1990 to 2017, particularly in males in high-SDI countries, some low-SDI and middle-SDI countries saw increasing prevalence in females.<sup>61</sup> Alcohol use did not show similar rates of decline, which is unlikely to change in the absence of effective legal instruments and taxation policies.<sup>62-65</sup> Further research is needed to understand the role of attitudes and practices associated with smoking and alcohol use by sex.<sup>66-70</sup>

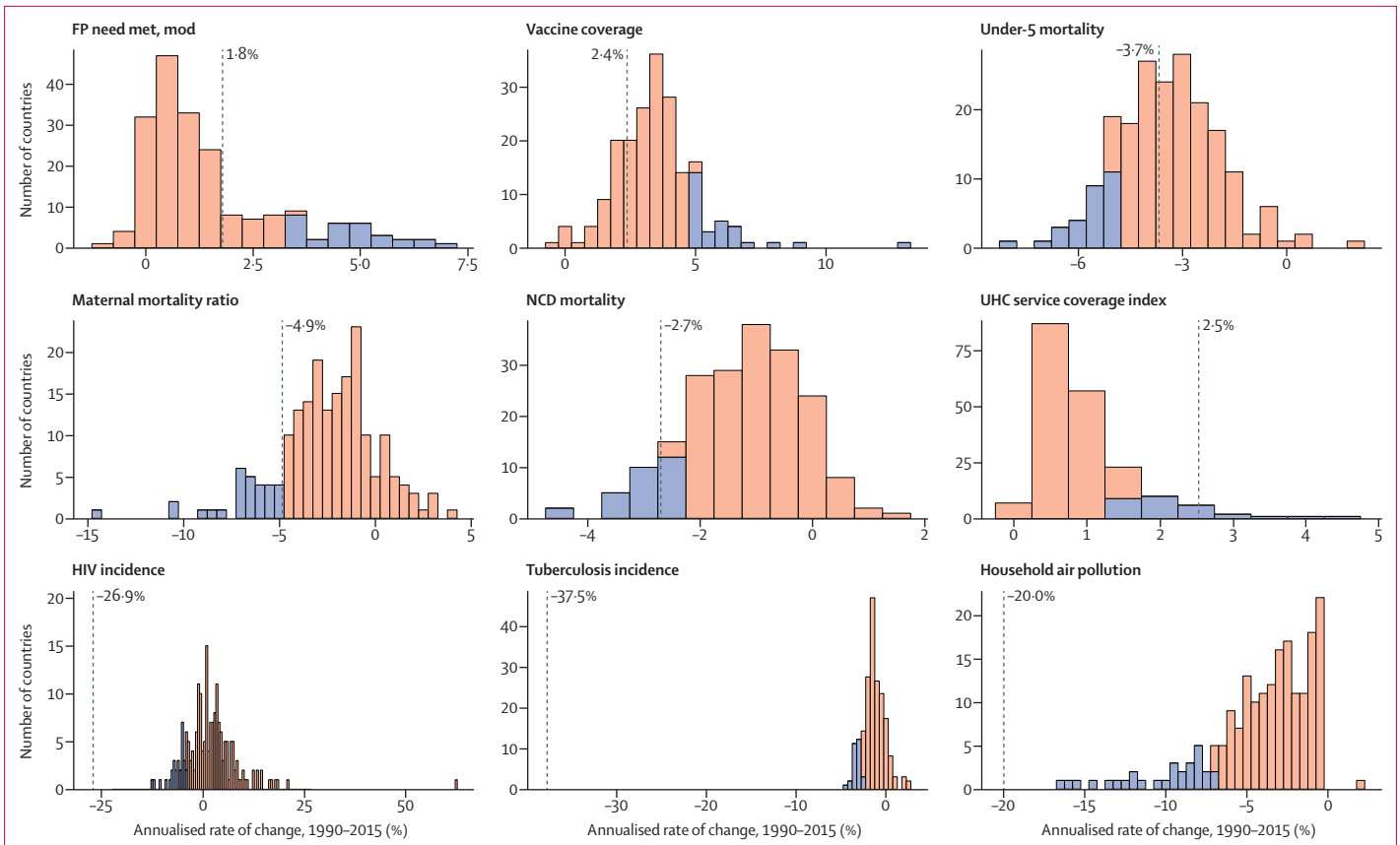
### Measuring progress at the subnational level

It is well known that national averages mask subnational disparities within countries, and the results of the health-related SDG index at the subnational level showed substantial differences in performance within countries, particularly in India and China. Differences between localities were lowest in Japan and the UK. Across countries, the states with the lowest SDG index scores in the USA (Mississippi, Arkansas, West Virginia, and Nevada) had lower scores than did 17 states in Mexico and 12 states in Brazil, while ten states in the USA had lower scores than Shanghai.

Disparities on the health-related SDGs at the subnational level were particularly pronounced among low-SDI and middle-SDI countries, indicating that greater investments in targeting the most vulnerable or disadvantaged people in a country are probably required to improve the health of the entire population. Generally, we found that higher-SDI countries had less variation in their performance among first administrative levels; however, differences at more focal levels (eg, counties in the USA and municipalities in Brazil) and by age and sex might still present considerable challenges to reaching the SDG aims of leaving no one behind. Identifying such gaps is a necessary first step to focus the attention of local decision makers when targeting resources and

**Figure 5: Comparing the probability of attainment for defined health-related SDG indicator targets based on past trends, by location, in 2030**

Countries and territories are ranked from highest to lowest by the total number of SDG indicator targets they are projected to attain on the basis of mean estimates for 2030. Numbers preceding the country names are the numbers of targets projected to be met by each country or territory based on means. Values reported reflect the probability of projected attainment based on the percentage of draws that fell above or below defined targets in 2030. Of the 41 health-related indicators measured in this study, 25 had defined targets linked to each indicator. SDG target 3.6 aims to reduce road injury mortality by 50% between 2015 and 2020, and thus attainment for this indicator is based on estimates from 2015 to 2020 rather than 2015 to 2030. Definitions of health-related SDG indicators and targets associated with them, as well as the specific target thresholds applied, are shown in table 1. FP=need met, mod=family planning need met with modern contraception methods. NCD=non-communicable disease. Non-int=non-intimate. NTD=neglected tropical disease. reg=registration. SDG=Sustainable Development Goal. UHC=universal health coverage.



**Figure 6:** Global annualised rate of change required to meet selected SDG targets based on annualised rate of change achieved by countries or territories, 1990–2015

For the 25 SDG indicators with defined targets, we estimated the required global annualised rate of change (dotted line) required to meet each target using the global average in 2015 and specific thresholds to be met by 2030 or relative reductions to be achieved by 2030. The top performing decile (the 10th decile) is shown in blue and all other annualised rates of change are shown in red. A subset of SDG indicators with defined targets are shown here; the remaining plots can be found in appendix 2. Definitions of health-related SDG indicators and targets associated with them are shown in table 1. FP need met, mod=family planning need met with modern contraceptive methods. NCD=non-communicable disease. SDG=Sustainable Development Goal. UHC=universal health coverage.

programmes. Few reports of countries seeking to address SDGs at the local level exist, although many countries have published voluntary reports of SDG progress with national-level data.<sup>71–77</sup>

Owing to the broad and multisectoral nature of the health-related SDG indicators, a whole-government approach is needed to strengthen their monitoring. Data are needed to inform planning and investment. Disaggregation of data can empower local administrations and improve local health information systems—an important government need beyond reporting indicator progress—but it is unlikely that it will be sufficient to identify all health inequalities.<sup>19,20</sup> The increased number of national and subnational units included in GBD 2017 is in line with the recommendation of the High Level Political Forum on Sustainable Development to produce regular voluntary national reviews of progress at national and subnational levels.<sup>78</sup> The production of subnational estimates for the GBD study is not intended to substitute for country-level reporting; on the contrary, we hope that the dissemination of these results might help stimulate subnational reporting in a proactive manner.<sup>79</sup>

### Setting and assessing SDG targets

Projected attainment differed substantially among indicators with defined SDG targets. This pattern was particularly true for indicators that had few countries projected to meet targets based on mean values but had relatively more countries that showed some probability of attaining them by 2030. For some indicators with strong links to the Millennium Development Goals era—eg, maternal mortality ratio, child mortality, malaria, and skilled birth attendance—more than 50% of countries were projected to meet 2030 targets; furthermore, of those countries not projected to achieve these targets based on their mean values, many showed some probability of attainment by 2030. These findings highlight possible trajectories for meeting targets if progress can be accelerated in the future.

Nonetheless, based on past rates of progress, no country is currently on track to meet all defined health-related SDG targets. For under-5 mortality, which has many countries on track for or already achieving the target of 25 deaths or fewer per 1000 livebirths by 2030, 31 countries or territories would need to achieve annual

|   | 2030 target used in this analysis     | Projected attainment in 2030 | Global average in 2015        | Global required annualised rates of change to meet SDG target by 2030 | Global percentile based on country-level annualised rates of change from 1990 to 2015 | Country-level annualised rates of change from 1990 to 2015 based on the mean percentiles for defined targets (90th percentile) | Global average in 2030        | Global percentage change, 2015–30 |
|---|---------------------------------------|------------------------------|-------------------------------|---|---|--|-------------------------------|-----------------------------------|
| Indicator 1.5.1: Death rate due to exposure to forces of nature   | Undefined                             | ..                           | 0.2 per 100 000 population    | ..  | ..  | -9.3%  | 0.05 per 100 000 population   | -76.8%                            |
| Indicator 2.2.1: Prevalence of stunting in children younger than 5 years  | ≤0.5%                                 | 0%                           | 28.7%                         | -27.0%  | 100   | -3.1%  | 18.0%                         | -37.6%                            |
| Indicator 2.2.2a: Prevalence of wasting in children younger than 5 years  | ≤0.5%                                 | 1%                           | 8.0%                          | -18.5%  | 100   | -3.2%  | 5.0%                          | -38.3%                            |
| Indicator 2.2.2b: Prevalence of overweight in children aged 2–4 years   | ≤0.5%                                 | 0%                           | 15.9%                         | -23.1%  | 100   | -0.5%  | 15.8%                         | -0.5%                             |
| Indicator 3.1.1: Maternal mortality ratio in females aged 10–54 years   | <70 deaths per 100 000 livebirths     | 56%                          | 145.0 per 100 000 livebirths  | -4.9%   | 86  | -6.0%  | 57.0 per 100 000 livebirths   | -60.7%                            |
| Indicator 3.1.2: Proportion of births attended by skilled health personnel  | ≥99%                                  | 54%                          | 80.1%                         | 1.4%  | 76  | 3.0%   | >99%                          | >22.8%                            |
| Indicator 3.2.1: Under-5 mortality rate   | ≤25 deaths per 1000 livebirths        | 72%                          | 43.3 per 1000 livebirths      | -3.7%   | 56  | -5.2%  | 19.4 per 1000 livebirths      | -55.3%                            |
| Indicator 3.2.2: Neonatal mortality rate  | ≤12 deaths per 1000 livebirths        | 71%                          | 18.6 per 1000 livebirths      | -2.9%   | 58  | -5.0%  | 8.6 per 1000 livebirths       | -53.7%                            |
| Indicator 3.3.1: Age-standardised rate of new HIV infections  | ≤0.005 per 1000 population            | 4%                           | 0.3 per 1000 population       | -26.9%  | 100   | -5.0%  | 0.1 per 1000 population       | -53.4%                            |
| Indicator 3.3.2: Age-standardised rate of tuberculosis cases  | ≤0.5 per 100 000 population           | 0%                           | 139.6 per 100 000 population  | -37.6%  | 100   | -2.9%  | 89.9 per 100 000 population   | -35.6%                            |
| Indicator 3.3.3: Age-standardised rate of malaria cases   | ≤0.005 per 1000 population            | 61%                          | 31.8 per 1000 population      | -58.4%  | 97  | -17.1%   | 1.9 per 1000 population       | -94.0%                            |
| Indicator 3.3.4: Age-standardised rate of hepatitis B incidence   | Undefined                             | ..                           | 2123.8 per 100 000 population | ..  | ..  | -0.6%  | 1955.2 per 100 000 population | -7.9%                             |
| Indicator 3.3.5: Age-standardised prevalence of the sum of 15 neglected tropical diseases   | ≤0.5%                                 | 24%                          | 18.2%                         | -24.0%  | 100   | -4.3%  | 9.4%                          | -48.2%                            |
| Indicator 3.4.1: Age-standardised death rate due to cardiovascular disease, cancer, diabetes, and chronic respiratory disease in populations aged 30–70 years | Reduce by one-third from 2015 to 2030 | 0%                           | 382.7 per 100 000 population  | -2.7%   | 91  | -2.6%  | 258.2 per 100 000 population  | -32.5%                            |
| Indicator 3.4.2: Age-standardised death rate due to self-harm   | Reduce by one-third from 2015 to 2030 | 0%                           | 10.0 per 100 000 population   | -2.7%   | 93  | -2.5%  | 6.8 per 100 000 population    | -31.4%                            |
| Indicator 3.5.2: Risk-weighted prevalence of alcohol consumption, as measured by the summary exposure value or alcohol use                                    | Undefined                             | ..                           | 11.6%                         | ..  | ..  | -1.4%  | 9.4%                          | -18.7%                            |
| Indicator 3.6.1: Age-standardised death rate due to road injuries   | Reduce by 50% from 2015 to 2020       | 0%                           | 16.1 per 100 000 population   | -13.9%  | 100   | -4.3%  | 13.0 per 100 000 population   | -19.6%                            |
| Indicator 3.7.1: Proportion of females of reproductive age (15–49 years) who have their need for family planning satisfied with modern contraception methods  | ≥99%                                  | 0%                           | 75.7%                         | 1.8%  | 72  | 4.1%   | >99%                          | >27.3%                            |
| Indicator 3.7.2: Number of livebirths per 1000 females aged 10–19 years   | Undefined                             | ..                           | 21.7 per 1000 females         | ..  | ..  | -4.2%  | 11.4 per 1000 females         | -47.4%                            |
| Indicator 3.8.1: Coverage of essential health services, as defined by the universal health coverage index   | ≥99%                                  | 0%                           | 67.7                          | 2.5%  | 97  | 1.8%   | 88.3                          | 30.4%                             |
| Indicator 3.9.1: Age-standardised death rate attributable to household air pollution and ambient air pollution  | Undefined                             | ..                           | 55.6 per 100 000 population   | ..  | ..  | -3.5%  | 32.5 per 100 000 population   | -41.5%                            |
| Indicator 3.9.2: Age-standardised death rate attributable to unsafe water, sanitation, and hygiene  | Undefined                             | ..                           | 35.7 per 100 000 population   | ..  | ..  | -7.3%  | 11.4 per 100 000 population   | -68.1%                            |

(Table 2 continues on next page)

|  | 2030 target used in this analysis | Projected attainment in 2030 | Global average in 2015       | Global required annualised rates of change to meet SDG target by 2030 | Global percentile based on country-level annualised rates of change from 1990 to 2015 | Country-level annualised rates of change from 1990 to 2015 based on the mean percentiles for defined targets (90th percentile) | Global average in 2030       | Global percentage change, 2015–30 |
|--|-----------------------------------|------------------------------|------------------------------|---|---|--|------------------------------|-----------------------------------|
| (Continued from previous page)   |                                   |                              |                              |   |   |  |                              |                                   |
| Indicator 3.9.3: Age-standardised death rate due to unintentional poisonings   | Undefined                         | ..                           | 1.0 per 100 000 population   | ..  | ..  | -4.7%  | 0.5 per 100 000 population   | -51.5%                            |
| Indicator 3.a.1: Age-standardised prevalence of current smoking in populations aged 10 years and older   | Undefined                         | ..                           | 18.4%                        | ..  | ..  | -1.6%  | 14.4%                        | -21.9%                            |
| Indicator 3.b.1: Coverage of eight vaccines among target populations   | ≥99%                              | 3%                           | 69.3%                        | 2.4%  | 23  | 5.2%   | >99%                         | >42.7%                            |
| Indicator 3.c.1: Health worker density (physicians, nurses and midwives, and pharmacists) per 1000 population  | Undefined                         | ..                           | 5.9 per 1000 population      | ..  | ..  | 4.2%   | 10.9 per 1000 population     | 85.4%                             |
| Indicator 5.2.1: Age-standardised prevalence of ever-partnered females aged 15 years and older who experienced physical or sexual violence by a current or former intimate partner in the past 12 months | ≤0.5%                             | 0%                           | 13.4%                        | -21.9%  | 100   | -1.4%  | 10.9%                        | -18.5%                            |
| Indicator 5.2.2: Age-standardised prevalence of females aged 15 years and older who experienced physical or sexual violence by non-intimate partner in the past 12 months                                | ≤0.5%                             | 21%                          | 1.0%                         | -4.3%   | 100   | 0.2%   | 1.0%                         | 3.5%                              |
| Indicator 6.1.1: Risk-weighted prevalence of populations using unsafe or unimproved water sources, as measured by the summary exposure value for unsafe water  | ≤1%                               | 13%                          | 34.3%                        | -23.6%  | 100   | -4.3%  | 17.7%                        | -48.3%                            |
| Indicator 6.2.1a: Risk-weighted prevalence of populations using unsafe or unimproved sanitation, as measured by the summary exposure value for unsafe sanitation   | ≤1%                               | 10%                          | 31.7%                        | -23.1%  | 100   | -6.2%  | 12.2%                        | -61.4%                            |
| Indicator 6.2.1b: Risk-weighted prevalence of populations without access to a handwashing facility, as measured by the summary exposure value for unsafe hygiene   | ≤1%                               | 0%                           | 33.2%                        | -23.3%  | 100   | -2.5%  | 22.8%                        | -31.3%                            |
| Indicator 7.1.2: Risk-weighted prevalence of household air pollution, as measured by the summary exposure value for household air pollution  | ≤1%                               | 34%                          | 20.1%                        | -20.0%  | 100   | -8.3%  | 5.5%                         | -72.6%                            |
| Indicator 8.8.1: Age-standardised all-cause disability-adjusted life-years attributable to occupational risks  | Undefined                         | ..                           | 830.0 per 100 000 population | ..  | ..  | -1.7%  | 646.2 per 100 000 population | -22.1%                            |
| Indicator 11.6.2: Population-weighted mean levels of PM <sub>2.5</sub>   | Undefined                         | ..                           | 47.5                         | ..  | ..  | -0.9%  | 41.4                         | -12.9%                            |
| Indicator 16.1.1: Age-standardised death rate due to interpersonal violence  | Undefined                         | ..                           | 5.1 per 100 000 population   | ..  | ..  | -3.3%  | 3.1 per 100 000 population   | -39.1%                            |
| Indicator 16.1.2: Death rate due to conflict and terrorism (per 100 000 population)  | Undefined                         | ..                           | 1.9 per 100 000 population   | ..  | ..  | -47.5%   | <0.01 per 100 000 population | -100.0%                           |
| Indicator 16.1.3a: Age-standardised prevalence of physical violence experienced by populations in the past 12 months   | Undefined                         | ..                           | 7.8%                         | ..  | ..  | -0.1%  | 7.7%                         | -0.9%                             |
| Indicator 16.1.3c: Age-standardised prevalence of sexual violence experienced by populations in the past 12 months   | Undefined                         | ..                           | 3.3%                         | ..  | ..  | -0.9%  | 2.9%                         | -12.1%                            |
| Indicator 16.2.3: Age-standardised prevalence of females and males aged 18–29 years who experienced sexual violence by age 18 years  | ≤0.5%                             | 0%                           | 9.8%                         | -19.8%  | 100   | -0.1%  | 9.6%                         | -1.8%                             |

(Table 2 continues on next page)

|   | 2030 target used in this analysis | Projected attainment in 2030 | Global average in 2015 | Global required annualised rates of change to meet SDG target by 2030 | Global percentile based on country-level annualised rates of change from 1990 to 2015 | Country-level annualised rates of change from 1990 to 2015 based on the mean percentiles for defined targets (90th percentile) | Global average in 2030 | Global percentage change, 2015–30 |
|---|-----------------------------------|------------------------------|------------------------|---|---|--|------------------------|-----------------------------------|
| (Continued from previous page)  |                                   |                              |                        |   |   |  |                        |                                   |
| Indicator 17.19.2c: Percentage of well-certified deaths by a vital registration system among a country's total population | ≥80%                              | 37%                          | 43.5%                  | 4.1%  | 98  | 1.9%   | 57.4%                  | 32.0%                             |

Using the global average observed in 2015 for each of the 25 health-related indicators with defined targets, we calculated the global annualised rates of change required to meet these targets by 2030 (or by 2020 in the case of road injury mortality). The global required annualised rates of change were then compared with country-level annualised rates of change calculated from 1990 to 2015. The percentiles in which the global required annualised rates of change fell among country-level annualised rates of change in the past were ascertained, and then the average of these percentiles was computed (90th percentile) to serve as a way to assess defined SDG targets and potential targets for indicators that do not currently have defined SDG targets. The 90th percentile annualised rates of change observed for each indicator was applied to the global average in 2015 to compute the equivalent average in 2030 and percentage change from 2015 to 2030 if these rates of change are achieved during the SDG era. SDG=Sustainable Development Goal.

Table 2: Predicting global attainment of health-related SDG indicators on the basis of past pace of progress observed across countries

rates of decline from 2015 to 2030 that are two to ten times higher than what was recorded for 1990–2015. To bring such ambition closer to reality for all populations, the UN and other agencies will need to provide technical leadership and financial support, particularly for the countries with the lowest health-related SDG performance.

A subset of SDG indicators, such as NCD mortality and suicide mortality, represent both the expansion of the SDG agenda to encompass broader health priorities beyond the narrower focus of the Millennium Development Goals and the establishment of ambitious yet potentially more feasible targets to meet within a 15 year time frame. At first glance, reducing NCD or suicide mortality by a third from 2015 to 2030—on average, the equivalent of a 2.7% reduction per year—might not seem particularly ambitious. Yet, amid the rising number of total deaths due to NCDs and challenges associated with providing quality NCD services in many countries,<sup>23,34</sup> this rate of change ranked in the 91st to 93rd percentiles of country-level annualised rates of change achieved from 1990 to 2015. However, to truly eliminate many health challenges, as the SDGs set out to do by 2030, most—if not all—countries will need to achieve rates of change that surpass those ever achieved in the past. This is particularly true for child overweight, for which most countries have only seen rising prevalence since 1990; tuberculosis, a disease that has received comparably less international funding than have HIV and malaria;<sup>79</sup> road injury mortality; and most non-fatal violence measures. All countries had less than 5% probability of attaining child overweight and road injury mortality targets, highlighting priority areas for intervention globally.

Our global attainment analysis, which is grounded in historical rates of change, offers a mechanism to assess the ambitiousness of undefined targets. For instance, SDG target 3.a calls for strengthening the implementation of the WHO Framework Convention on Tobacco Control

in all countries, a target against which changes in current smoking prevalence are not easily evaluated. The 90th mean global percentile of country-level rates of change in current smoking prevalence was a 1.6% decline per year from 1990 to 2015, which equated to a 21.9% decrease from 2015 to 2030 at the global level. Notably, the GPW13 calls for a 25% reduction in current tobacco use within 5 years (ie, a 5.8% decline per year),<sup>3</sup> a pace that far exceeds what countries have achieved in the recent past.

The setting of targets is both a technical and political exercise, aiming to balance important societal objectives with the reality that many bold targets might be challenging, if not impossible, to achieve within short periods of time. Instituting targets solely on the basis of past rates of change and data is unlikely to happen within global and national policy circles; even if it could occur, such an approach might be equally unhelpful given that galvanising new funds, innovations, and commitments to improving population health worldwide often requires setting sights beyond what seems possible today. Instead, we hope that the methods used in this study will be useful in providing technical underpinnings for setting realistic and achievable targets; in the long run, such targets are likely to be more effective in driving action. We view these results as an important entry point for charting possible pathways to accelerated gains by 2030, as well as identifying more tangible interim goalposts against which countries can track ongoing advances and needs. As the Inter-agency and Expert Group on Sustainable Development Goal Indicators and UN Statistical Commission prepare for their formal review and revision of the global indicator framework in 2020, these findings might serve as inputs for consideration.

The perceived feasibility of target attainment can shape how international institutions, funding agencies, and countries approach health challenges. In particular, strict interpretation of the UN's targets for elimination or universal coverage sets very high bars for success (eg, 100% coverage or elimination). Although elimination

has been achieved for some diseases in various settings (eg, malaria and a subset of neglected tropical diseases), truly ending an epidemic is much more complex for others, especially in the absence of fully effective vaccines or a radical cure. For other SDG indicators, such as intimate partner violence, elimination should be wholly feasible; yet to completely end all violent acts would require societal, cultural, political, and legal structures to fully align. Without more concrete strategies and funding for elimination, setting such ambitious targets could risk setting countries up for short-term failure and longer-term obstacles to instituting sustainable programmes; such arguments have been recently made about ambitions to eliminate HIV.<sup>80</sup> Nonetheless, HIV remains a massive public health threat, particularly because global financing has plateaued, domestic health spending on HIV has stayed low among high-burden countries,<sup>79</sup> and its incidence has not declined as quickly in younger as in older populations.<sup>26</sup> It could also be argued that aiming for elimination but falling short in 2030 would still substantially improve the lives of millions and facilitate medical breakthroughs that might not be funded without a global elimination campaign. How best to galvanise accelerated action against the world's largest health challenges is far from clear; going forward, the GBD study can offer international agencies and countries alike a platform through which different operationalisations of SDG targets can be tested.

#### Comparisons with other assessments

International agencies and the GBD study began producing annual reports of country estimates for the health-related SDG indicators in 2016. Of the 52 health-related indicators, GBD 2017 reported on 41, WHO reported on 37 in its 2018 World Health Statistics report,<sup>6</sup> the World Bank covered 33 in its 2018 SDG Atlas,<sup>7</sup> and the Sustainable Development Solutions Network included 27.<sup>4</sup> Standardisation of definitions and methods used to calculate the health-related SDG indicators could improve comparability across organisations and collaborations involved in monitoring the SDGs. The complete set of metadata for SDG indicators, provided by the UN and other international organisations, comes with instructions on how indicators should be measured.<sup>81</sup> However, GBD approaches to measurement differ from WHO approaches in various ways. For example, we use age-standardised rates for indicators that include mortality or incidence (eg, NCD mortality, suicide mortality, probability of death), whereas WHO generally use all-age rates. Furthermore, we define child overweight in terms of body-mass index for age and sex to align with the definition of overweight and obesity for adults, rather than in terms of weight for height. We also include all women of reproductive age in measurement of the met need for family planning indicator rather than limiting this measure to only women who are married or in a union. GBD also offers estimates for more years

and locations than other organisations currently do, supporting the overarching SDG endeavour of leaving no one behind.

#### Strengths

An important strength of GBD 2017 is the increasing number of collaborators involved: participation increased by more than 44% from 2016, with collaborators from 144 countries and two territories. The collaborator network offers multiple benefits to the GBD study, and in the case of the SDGs, it provides the particular benefit of supporting international and national policy dialogue, connecting technical information to the political needs of the health-related SDGs. Health programmes and plans have a limited chance of success in the absence of robust evidence and policy dialogue. The benchmarking presented in GBD 2017 can help countries to promote and increase accountability at the national level. The bottom line is the need to enhance mutual understanding of the SDG agenda across the entire global range of stakeholders and to champion the importance of national ownership of local guidance, monitoring, and management in achieving SDG targets.

To facilitate comparisons across locations and over time of the diverse array of health-related SDG indicators, we have produced an overall SDG index since GBD 2015.<sup>5,13</sup> The health-related SDG index is not presented in lieu of monitoring individual indicators, which we also do here. Instead, this index provides a mechanism by which overall performance across health-related SDGs can be more easily compared. A single, robust measurement such as the health-related SDG index is a useful tool for policy makers and other decision makers to interpret the performance of a particular location. With the production of time trends for several indicators, the SDG index also facilitates the understanding of the pace of progress. While index values represent a combination of different dimensions considered together as a proxy of health-related SDG indicator performance, results reported by individual indicator allow for more nuanced analyses.

#### Limitations of indicator measurement

Our measurement of the health-related SDG indicators is subject to the limitations of the broader GBD 2017 study and its estimation processes; details can be found in the accompanying GBD 2017 capstone papers<sup>23–27</sup> and in appendix 1 (part 1). Beyond these limitations, there are other important limitations that are specific to this analysis.

First, for measurement of health worker density we used ISCO 88 codes as the base classification system instead of ISCO 08, which is a more recent system than ISCO 88 that offers greater detail and standardisation. However, few occupational data sources currently include ISCO 08 codes, and benchmarking all past surveys to ISCO 08 would have resulted in substantial information

loss. In future GBD iterations, we aim to collate more recent occupational data and to further refine health worker cadre mapping. Additionally, the UN includes density of dentist personnel in health worker density estimates, but the GBD study does not because including the four health cadres leads to counterintuitive results. Finally, the measure of health worker density can reveal only the quantity, not the quality, of available care.

Second, continued data sparsity for many violence measures, particularly for males and non-intimate partners, results in comparatively high uncertainty for these SDG indicators. Data on the prevalence of any form of violence are also subject to a number of measurement biases. All data for these indicators are self-reported and subject to recall bias and varying interpretations of survey questions. Variation in case-definitions or survey questions used by different surveys might also lead to increased uncertainty. We did not estimate psychological violence because there was no good standard for how to consistently measure it. Cultural influences, legal barriers to reporting, and stigma can also lead to underreporting and make the interpretation of self-reported data challenging, particularly for sensitive topics such as violence and other self-reported SDG indicators. Suicide is another indicator that might be affected by religious, cultural, and legal barriers to reporting. Accurate monitoring of violence measures requires routine, carefully implemented data collection, experienced interviewers, and thoughtful design for data intake, as well as ensuring that adequate protections and resources are available for victims of violence.

Third, owing to overall data sparsity, many challenges remain in modelling of both temporal and age patterns for non-fatal health outcomes; for the SDGs, this challenge is particularly pronounced for hepatitis B. Our current hepatitis B vaccine coverage covariate, a key input into hepatitis B incidence modelling, is limited to infant vaccination coverage. Because the current iteration of DisMod-MR cannot accommodate age-specific covariates, the effects of vaccination in older children and young adults for countries with long-running hepatitis B vaccination programmes (eg, Taiwan [province of China]) are not well captured. A priority of future GBD iterations is to use a version of DisMod that will allow for age-specific covariates, which will benefit hepatitis B modelling. Additionally, expanding the underlying data inputs for hepatitis seroprevalence, particularly for age groups that have benefited from vaccination programmes, has the potential to substantially improve hepatitis B estimation; for instance, the Polaris Observatory has markedly increased its seroprevalence data collection efforts in recent years, and such data have yet to be incorporated into the GBD study.

Fourth, our estimates of UHC currently only capture service coverage and do not include the second dimension of financial risk protection. The addition of

financial risk protection and catastrophic health spending is a priority for future iterations of the GBD study. Ongoing review by the WHO Task Force on Metrics for GPW13 will likely yield recommendations that will inform future GBD revisions of how to measure UHC service coverage.

Fifth, the UN's metadata definition for vaccine coverage includes the human papillomavirus vaccine, but we do not currently include this vaccine owing to the limited number of countries with available data. Future iterations of the GBD study will aim to estimate human papillomavirus vaccine coverage.

Sixth, conflicts and refugee populations might affect SDG indicator trends in ways not well captured by our data. Although these factors introduce additional uncertainty to our estimates, these populations cannot be ignored, and GBD strives to make the best estimates based on the available data.

#### Limitations of forecasting and attainment analyses

Generating forecasts has inherent limitations: when forecasts are grounded in past rates of change, we cannot fully account for what might occur between now and 2030, including changes in health financing and global health priorities, conflict, and climate change. Positive developments, such as new medical advances, can be challenging to predict, as are negative events, such as the emergence of drug resistance. Continued improvements in our overall forecasting framework and specific approaches by cause, risk, and intervention have the potential to further advance our ability to understand how and where the largest challenges in making progress on the health-related SDGs might occur.

#### Limitations of indicator scaling and index construction

Ideally, we would systematically implement a scaling approach that accounts for the lowest possible levels of avoidable mortality, non-fatal outcomes, and risk exposures given current medical technologies and population-level interventions and the highest levels of coverage conditional upon measurable scale-up constraints or system inefficiencies. Scaling these indicators to the 2.5th and 97.5th percentiles of 1000 draws over time approximates this approach and allows consistent comparison of performance across indicators and locations. Nonetheless, our scaling strategy can either mask the potential for further improvements or imply worse performance, especially in relation to more modest SDG targets. Although the addition or refinement of new health-related SDG indicators with each GBD cycle is viewed as supportive of a more comprehensive assessment of the health-related SDGs, such updates can result in changes in individual countries' overall index values and relative rankings (appendix 2). These changes reflect our efforts to collectively improve the data for and science of monitoring the health-related SDGs. Overall index scores can be affected by indicators linked to fatal

discontinuities, whereby an abrupt increase in deaths one year might not be present in the following year. We continue to use the geometric mean for the health-related SDG index. This decision might result in lower overall index scores for some locations if they experience worsening performance on particular indicators; however, it provides a more direct reflection of how the SDGs have been established by the UN and UN member states.<sup>82</sup>

### Limitations of data availability and disaggregation

GBD data are currently only available by sex, and not by gender, which limits the scope of analyses that can be conducted. The binary application of sex does not encompass differences in transgender and other populations. We currently only present data disaggregated by sex for ten indicators. Further collection and disaggregation of data would strengthen the ability of the GBD to support additional sex-specific analyses. For some new indicators, such as violence, some countries have better data collection systems in place than do others, and increased data collection is needed to make accurate comparisons between countries. Overall, the availability and representativeness of reported numbers from each country, particularly low-SDI and middle-SDI countries, could be improved by increased data collection, surveillance, and reporting at the national level.

### Future directions

Important refinements to our estimation process are made with each GBD iteration. As discussed already, one priority is to improve our measurement of UHC service coverage (SDG indicator 3.8.1), generate comprehensive estimates of catastrophic health expenditures (SDG indicator 3.8.2), and then ultimately develop an overall measure of UHC. In theory, UHC service coverage and catastrophic health expenditures (the inverse of financial risk protection) should be linked; however, to date, their measurement has generally involved separate endeavours. GBD and collaborators are working to update estimates of UHC in this direction in the near future, in line with the WHO/World Bank framework.<sup>83</sup> We currently use the arithmetic mean to construct the UHC service coverage index; however, other methods of index construction might be considered for future analyses. Other future priorities include analysing results by age as well as by sex, generating subnational projections, decomposing potential drivers of indicator-level progress, and further advancing the quantity and quality of data used in overall GBD estimation. Two other indicators, coverage of substance use disorder treatment (SDG indicator 3.5.1) and populations who feel safe walking home alone (SDG indicator 16.1.4), also are candidates for future inclusion pending data availability and access. Furthermore, it might be worthwhile to revisit what constitutes health-related SDGs, particularly as the UN Statistical Commission prepares for its formal review of

current indicators and proposed additions. Finally, in view of the reasonably short window for the SDG era, there is increasing interest in developing model-based scenarios wherein the effects of investment “X” or introduction of intervention “Y” can be explored. The forecasting framework developed by Foreman and colleagues sets the foundation for such work<sup>36</sup> given that the causal relationships captured and propagated through projections can be set at different levels or altered in response to funding changes (eg, 10% budget cut and its effects on HIV).<sup>83</sup>

### Conclusion

International institutions are increasingly calling for disaggregated data to guide decision making in health, and the SDGs are no exception. The SDG health-related index varied greatly at the subnational level in many countries, reflecting the need to focus on subnational health inequalities in the SDG era. Globally, males generally experienced a greater toll than did females from the ten health-related indicators analysed, emphasising the importance of both health data and programmes that incorporate sex-specific dimensions. Although most countries were projected to have improved SDG index scores in 2030, progress is slower than what is needed to attain defined targets across a wide range of health domains, including NCDs, which have many recommended best buy policies that have yet to be widely implemented. Countries and supporting international agencies must move beyond commitment to implementation, with a special focus on monitoring gains and gaps on the health-related SDGs beyond national trends. As shown by past rates of country-level progress, we have the opportunity to catalyse substantial gains in the future if the right investments and focus can occur today.

#### GBD 2017 SDG Collaborators

Rafael Lozano, Nancy Fullman, Degu Abate, Solomon M Abay, Cristiana Abbafati, Nooshin Abbasi, Hedayat Abbastabar, Foad Abd-Allah, Jemal Abdela, Ahmed Abdelalim, Omar Abdel-Rahman, Alireza Abdi, Ibrahim Abdollahpour, Rizwan Suliankatchi Abdulkader, Nebiyu Dereje Abebe, Zegeye Abebe, Ayenew Negesse Abeje, Semaw F Abera, Olifan Zewdie Abil, Victor Aboyans, Haftom Niguse Abraha, Aklilu Roba Abrham, Laith Jamal Abu-Raddad, Niveen Me Abu-Rmeileh, Gebre Y Abyu, Manfred Mario Kokou Accrombessi, Dilaram Acharya, Pawan Acharya, Abdu A Adamu, Oladimeji M Adebayo, Isaac Akinkunmi Adedeji, Rufus Adesoji Adedoyin, Victor Adekanmbi, Olatunji O Adetokunboh, Beyene Meressa Adhena, Tara Ballav Adhikari, Mina G Adib, Arsène Kouablan Adou, Jose C Adsuar, Mohsen Afarideh, Mahdi Afshari, Ashkan Afshin, Gina Agarwal, Sargis Aghasi Aghayan, Dominic Agius, Anurag Agrawal, Sutapa Agrawal, Alireza Ahmadi, Mehdi Ahmadi, Hamid Ahmadi, Muktar Beshir Ahmed, Sayem Ahmed, Temesgen Yihunie Akalu, Ali S Akanda, Mohammad Esmaeil Akbari, Mohammed Akibu, Rufus Olusola Akinyemi, Tomi Akinyemiju, Nadia Akseer, Fares Alahdab, Ziyad Al-Aly, Khurshid Alam, Tahiya Alam, Ammar Albujee, Animum Alebel, Kefyalew Addis Alene, Ayman Al-Eyadhy, Samia Alhabib, Raghib Ali, Mehran Alijanzadeh, Reza Alizadeh-Navaei, Syed Mohamed Aljunid, Ala'a Alkerwi, François Alla, Peter Allebeck, Christine A Allen, Ali Almasi,

Fatma Al-Maskari, Hesham M Al-Mekhlafi, Jordi Alonso, Rajaa M Al-Raddadi, Ubai Alsharif, Khalid Altirkawi, Nelson Alvis-Guzman, Azmeraw T Amare, Kebede Amenu, Erfan Amini, Walid Ammar, Nahla Hamed Anber, Jason A Anderson, Catalina Liliana Andrei, Sofia Androudi, Megbaru Debalkie Animut, Mina Anjomshoa, Hossein Ansari, Ansariadi Ansariadi, Mustafa Geleto Ansha, Carl Abelardo T Antonio, Palwasha Anwari, Lambert Tetteh Appiah, Olatunde Aremu, Habtamu Abera Areri, Johan Ärnlov, Monika Arora, Krishna K Aryal, Hamid Asayesh, Ephrem Tsegay Asfaw, Solomon Weldegebreal Asgedom, Rana Jawad Asghar, Suzaa Assadi, Zerihun Ataro, Suleman Atique, Sachin R Atre, Madhu Sudhan Atteraya, Marcel Ausloos, Leticia Avila-Burgos, Euripide F G A Avokpaho, Ashish Awasthi, Beatriz Paulina Ayala Quintanilla, Henok Tadesse Ayele, Yohanes Ayele, Rakesh Ayer, Mahmood Reza Azarpazhooh, Peter S Azzopardi, Natasha Azzopardi-Muscat, Tesleem Kayode Babalola, Arefeh Babazadeh, Hamid Badali, Alaa Badawi, Kalpana Balakrishnan, Ayele Geleto Bali, Maciej Banach, Amitava Banerjee, Joseph Adel Mattar Banoub, Amrit Banstola, Aleksandra Barac, Miguel A Barboza, Suzanne Lyn Barker-Collo, Till Winfried Bärnighausen, Lope H Barrero, Celine M Barthelemy, Quique Bassat, Arindam Basu, Sanjay Basu, Robert J Battista, Bernhard T Baune, Habtamu Wondifraw Baynes, Shahrzad Bazargan-Hejazi, Neeraj Bedi, Ettore Beghi, Masoud Behzadifar, Meysam Behzadifar, Yannick Béjot, Bayu Begashaw Bekele, Abate Bekele Belachew, Aregawi Gebreyesus Belay, Saba Abraham Belay, Yihalem Abebe Belay, Michelle L Bell, Aminu K Bello, Derrick A Bennett, Isabela M Bensenor, Habib Benzian, Adugnaw Berhane, Abadi Kidanemariam Berhe, Adam E Berman, Eduardo Bernabe, Robert S Bernstein, Gregory J Bertolacci, Mircea Beuran, Tina Beyranvand, Neeraj Bhala, Ashish Bhalla, Anil Bhansali, Suraj Bhattarai, Soumyadeep Bhaumik, Zulfiqar A Bhutta, Belete Biadgo, Molly H Biehl, Ali Bijani, Boris Bikbov, Nigus Bililign, Muhammad Shahdaat Bin Sayeed, Sait Menten Birlik, Charles Birungi, Donal Bisanzio, Tuhin Biswas, Helen Bitew, Hailemichael Bizuneh, Espen Bjertness, Eshetu Mulisa Bobasa, Soufiane Boufous, Rupert Bourne, Kayvan Bozorgmehr, Nicola Luigi Bragazzi, Michael Brainin, Luisa C Brant, Michael Brauer, Alexandra Brazinova, Nicholas J K Breitborde, Paul Svitol Briant, Gabrielle Britton, Traolach Brughá, Gene Bukhman, Reinhard Busse, Zahid A Butt, Lucero Cahuana-Hurtado, Charlton SKH Callender, Ismael R Campos-Nonato, Julio Cesar Campuzano Rincon, Jorge Cano, Jospic Car, Mate Car, Rosario Cárdenas, Juan J Carrero, Austin Carter, Félix Carvalho, Carlos A Castañeda-Orjuela, Jacqueline Castillo Rivas, Franz Castro, Kate Causey, Alanur Çavlin, Kelly M Cercy, Ester Cerin, Yazan Chaiah, Julian Chalek, Hsing-Yi Chang, Jung-Chen Chang, Aparajita Chattopadhyay, Vijay Kumar Chattu, Pankaj Chaturvedi, Peggy Pei-Chia Chiang, Ken Lee Chin, Vesper Hichilombwe Chisumpa, Abdulaal Chitheer, Jee-Young J Choi, Rajiv Chowdhury, Hanne Christensen, Devasahayam J Christopher, Sheng-Chia Chung, Flavia M Cicuttini, Liliana G Ciobanu, Massimo Cirillo, Rafael M Claro, Thomas Khaled Dwayne Claßen, Aaron J Cohen, Daniel Collado-Mateo, Cyrus Cooper, Leslie Trumbull Cooper, Leslie Cornaby, Monica Cortinovis, Megan Costa, Ewerton Cousin, Elizabeth A Cromwell, Christopher Stephen Crowe, Matthew Cunningham, Alemneh Kabeta Daba, Abel Fekadu Dadi, Lalit Dandona, Rakhi Dandona, Anh Kim Dang, Paul I Dargan, Ammad Daryani, Siddharth K Das, Rajat Das Gupta, José das Neves, Tamirat Tesfaye Dasa, Aditya Prasad Dash, Adrian C Davis, Dragos Virgil Davitioiu, Kairat Davletov, Anand Dayama, Barbara de Courten, Diego De Leo, Jan-Walter De Neve, Hans De Steur, Meaza Girma Degefa, Louisa Degenhardt, Tizta Tilahun Degfie, Selina Deiparine, Robert P Dellavalle, Gebre Teklemariam Demoz, Balem Demtsu, Edgar Denova-Gutiérrez, Kebede Deribe, Nikolaos Dervenis, Getenet Ayalew Dessie, Subhojit Dey, Samath D Dharmaratne, Meghnath Dhimal, Daniel Dicker, Mesfin Tadesse Dinberu, Eric L Ding, Shirin Djalalinia, Huyen Phuc Do, Klara Dokova, David Teye Doku, Dirk Douwes-Schultz, Tim Robert Driscoll, Leilei Duan, Manisha Dubey, Eleonora Dubljanin, Eyasu Ejeta Duken, Bruce B Duncan, Andre R Duraes, Soheil Ebrahimpour, David Edvardsson, Charbel El Bcheraoui, Erika Eldrenkamp, Ziad El-Khatib, Iqbal RF Elyazar, Ahmadali Enayati, Aman Yesuf Endries, Babak Eshtrati, Sharareh Eskandari, Alireza Esteghamati, Sadaf Esteghamati, Kara Estep, Mahdi Fakhar, Hamed Fakhim, Jessica Fanzo, Mahbobeh Faramarzi, Mohammad Fareed, Farzaneh Farhadi, Talha A Farid, Carla Sofia e Sá Farinha, Andrea Farioli, Andre Faro, Maryam S Farvid, Farshad Farzadfar, Mohammad Hosein Farzaei, Hossein Farzam, Ali Akbar Fazaeli, Mir Sohail Fazeli, Valery L Feigin, Andrea B Feigl, Wubalem Fekadu, Rachel Feldman, Netsanet Fentahun, Seyed-Mohammad Fereshtehnejad, Eduarda Fernandes, Joao C Fernandes, Garumma Tolu Feyissa, Daniel Obadare Fijabi, Irina Filip, Samuel Finegold, Jonas David Finger, Florian Fischer, Christina Fitzmaurice, Luisa Sorio Flor, Nataliya A Foigt, Kyle J Foreman, Tahvi D Frank, Richard Charles Franklin, Takeshi Fukumoto, Kai Fukutaki, John E Fuller, Thomas Fürst, João M Furtado, Emmanuela Gakidou, Silvano Gallus, Fortune Gbetoho Gankpe, Ron T Gansevoort, Ana Cristina Garcia, Alberto L Garcia-Basteiro, Miguel A Garcia-Gordillo, William M Gardner, Abadi Kahu Gebre, Teshome Gebre, Gebremedhin Berhe Gebregeregs, Tsegaye Tewelde Gebrehiwot, Amanuel Tesfay Gebremedhin, Bereket Gebremichael, Teklu Gebrehiwo Gebremichael, Tilayie Feto Gelano, Johanna M Geleijnse, Yilma Chisha Dea Geramo, Sefonias Getachew, Peter W Gething, Kebede Embaye Gezae, Mohammad Rasoul Ghadami, Reza Ghadimi, Keyghobad Ghadiri, Maryam Ghasemi-Kasman, Hesam Ghiasvand, Mamata Ghimire, Aloke Gopal Ghoshal, Simona Giampaoli, Paramjit Singh Gill, Tiffany K Gill, Giorgia Giussani, Elena V Gnedovskaya, Ellen M Goldberg, Srinivas Goli, Philimon N Gona, Amador Goodridge, Sameer Vali Gopalani, Taren M Gorman, Atsushi Goto, Alessandra C Goulart, Bárbara Niegia Garcia Goulart, Ayman Grada, Max G Griswold, Giuseppe Grosso, Harish Chander C Gugnani, Francis Guillemin, Andre Luiz Sena Guimaraes, Yuming Guo, Prakash C Gupta, Rahul Gupta, Rajeev Gupta, Tanush Gupta, Giang Hai Ha, Juanita A Haagsma, Vladimir Hachinski, Nima Hafezi-Nejad, Hassan Haghparast Bidgoli, Tekleberhan B Hagos, Michael Tamene Haile, Tewodros Tesfa Hailegiyorgis, Gessesew Bugssa Hailu, Arvin Haj-Mirzaian, Arya Haj-Mirzaian, Randah R Hamadeh, Samer Hamidi, Graeme J Hankey, Hilda L Harb, Sivadasanpillai Harikrishnan, Hamidreza Haririan, Josep Maria Haro, Mehdi Hasan, Hadi Hassankhani, Hamid Yimam Hassen, Rasmus Havmoeller, Caitlin N Hawley, Simon I Hay, Yihua He, Akbar Hedayatzadeh-Omran, Mohamed I Hegazy, Behzad Heibati, Behnam Heidari, Mohsen Heidari, Delia Hendrie, Anduaalem Henok, Ileana Heredia-Pi, Claudiu Herteliu, Behzad Heydarpour, Fatemeh Heydarpour, Sousan Heydarpour, Desalegn T Hibstu, Martha Híjar, Hans W Hoek, Daniel J Hoffman, Michael K Hole, Enayatollah Homaie Rad, Praveen Hoogar, Nobuyuki Horita, H Dean Hosgood, Seyed Mostafa Hosseini, Mehdi Hosseinzadeh, Mihaela Hostiu, Sorin Hostiu, Peter J Hotez, Damian G Hoy, Mohamed Hsairi, Thomas Hsiao, Guoqing Hu, John J Huang, Caitlyn Hughes, Chantal K Huynh, Ehimario U Igumban, Chad Thomas Ikeda, Olayinka Stephen Ilesanmi, Usman Iqbal, Seyed Sina Naghibi Irvani, Caleb Mackay Salpeter Irvine, Sheikh Mohammed Shariful Islam, Farhad Islami, Rebecca Q Ivers, Neda Izadi, Kathryn H Jacobsen, Leila Jahangiri, Nader Jahanmeh, Sudhir Kumar Jain, Mihajlo Jakovljevic, Moti Tolera Jalu, Amr A Jamal, Spencer L James, Simerjot K Jassal, Mehdi Javanbakht, Achala Upendra Jayatileke, Panniyammakal Jeemon, Ravi Prakash Jha, Vivekanand Jha, John S Ji, Catherine O Johnson, Sarah C Johnson, Jost B Jonas, Jitendra Jonnagaddala, Zahra Jorjoran Shushtari, Ankur Joshi, Jacek Jerzy Jozwiak, Suresh Banayya Jungari, Mikko Jürisson, Madhanraj K, Zubair Kabir, Rajendra Kadel, Amaha Kahsay, Molla Kahssay, Rizwan Kalani, Umesh Kapil, Manoochehr Karami, Behzad Karami Matin, Marina Karanikolos, Narges Karimi, Seyed M Karimi, Hamidreza Karimi-Sari, Amir Kasaeian, Dessalegn H Kassa, Getachew Mullu Kassa, Tesfaye Dessale Kassa, Zemenu Yohannes Kassa, Nicholas J Kassebaum, Srinivasa Vittal Katikireddi, Anil Kaul, Norito Kawakami, Zhila Kazemi, Ali Kazemi Karyani, Dhruv Satish Kazi, Prakash KC, Seifu Kebede, Peter Njenga Keiyoro, Laura Kemmer, Grant Rodgers Kemp, Andre Pascal Kengne, Andre Keren,

Chandrasekharan Nair Kesavachandran, Yousef Saleh Khader, Behzad Khafaei, Morteza Abdullatif Khafaei, Alireza Khajavi, Nauman Khalid, Ibrahim A Khalil, Ejaz Ahmad Khan, Muhammad Shahzeb Khan, Muhammad Ali Khan, Young-Ho Khang, Tripti Khanna, Mona M Khater, Alireza Khatouni, Zahra Khazaeipour, Habibolah Khazaie, Abdullah T Khoja, Ardeshir Khosravi, Mohammad Hossein Khosravi, Jagdish Khubchandani, Aliasghar A Kiadaliri, Helen W Kiarie, Getiye D Kibret, Daniel N Kiirithio, Daniel Kim, Jun Y Kim, Young-Eun Kim, Yun Jin Kim, Ruth W Kimokoti, Yohannes Kinfu, Sanjay Kinra, Adnan Kisa, Katarzyna Kissimova-Skarbek, Niranjana Kissoon, Mika Kivimäki, Jonathan M Kocarnik, Sonali Kochhar, Yoshihiro Kokubo, Tufa Kolola, Jacek A Kopec, Margaret N Kosek, Soewarta Kosen, Parvaiz A Koul, Ai Koyanagi, Michael A Kravchenko, Kewal Krishan, Kristopher J Krohn, Barthelemy Kuate Defo, Burcu Kucuk Bicer, Andreas A Kudom, Xie Rachel Kulikoff, G Anil Kumar, Manasi Kumar, Pushpendra Kumar, Michael J Kutz, Hmwe Hmwe Kyu, Carl Lachat, Deepesh P Lad, Sheetal D Lad, Alessandra Lafranconi, Abraham K Lagat, Dharmesh Kumar Lal, Ratilal Laloo, Hilton Lam, Faris Hasan Lami, Prabhat Lamichhane, Qing Lan, Justin J Lang, Van C Lansingh, Sonia Lansky, Heidi J Larson, Anders O Larsson, Dennis Odai Laryea, Zohra S Lassi, Arman Latifi, Kathrynn Mei-Ming Lau, Avula Lakshmaiah, Jeffrey V Lazarus, Janet L Leasher, Georgy Lebedev, Jorge R Ledesma, James B Lee, Paul H Lee, Andrew T Leever, James Leigh, Mall Leinsalu, Cheru Tesema Leshargie, Janni Leung, Sonia Lewycka, Shanshan Li, Xiaohong Li, Yichong Li, Juan Liang, Xiaofeng Liang, Misgan Legesse Liben, Lee-Ling Lim, Miteku Andualem Limenih, Shai Linn, Shiwei Liu, Yang Liu, Rakesh Lodha, Giancarlo Logroscino, Alan D Lopez, Stefan Lorkowski, Paulo A Lotufo, Lydia R Lucchesi, Ronan A Lyons, Erynn Rachelle King Macarayan, Mark T Mackay, Emilie R Maddison, Fabiana Madotto, Dhaval P Maghavani, Carlos Magis-Rodriguez, Narayan Bahadur Mahotra, Marek Majdan, Reza Majdzadeh, Azeem Majeed, Reza Malekzadeh, Deborah Carvalho Malta, Abdullah A Mamun, Ana-Laura Manda, Luiz Garcia Mandarano-Filho, Srikanth Mangalam, Helena Manguerra, Mohammad Ali Mansournia, Chabala Christopher Mapoma, Joemer C Maravilla, Wagner Marcenes, Ashley Marks, Randall V Martin, Sheila C O Martins, Francisco Rogerlândio Martins-Melo, Ira Martopullo, Tivani Phosa Mashamba-Thompson, Benjamin Ballard Massenburgh, Manu Raj Mathur, Pallab K Maulik, Mohsen Mazidi, Colm McAlinden, John J McGrath, Martin McKee, Brian J McMahon, Suresh Mehata, Man Mohan Mehendiratta, Ravi Mehrotra, Kala M Mehta, Varshil Mehta, Fabiola Mejia-Rodriguez, Tesfa Mekonen, Tefera C Chane Mekonnen, Hagazi Gebre Meles, Addisu Melese, Mulugeta Melku, Peter T N Memiah, Ziad A Memish, Walter Mendoza, Desalegn Tadesse Mengistu, Getnet Mengistu, George A Mensah, Gert B M Mensink, Seid Tiku Mereta, Atte Meretoja, Tuomo J Meretoja, Tomislav Mestrovic, Haftay Berhane Mezgebe, Bartosz Miazgowski, Tomasz Miazgowski, Anoushka I Millea, Ted R Miller, Molly Katherine Miller-Petrie, George J Milne, G K Mini, Shawn P Minnig, Parvaneh Mirabi, Mojdeh Mirarrefin, Erkin M Mirrakhimov, Awoke Temesgen Misganaw, Philip B Mitchell, Babak Moazen, Ali Akbar Moghadamnia, Bahram Mohajer, Karzan Abdulmuhsin Mohammad, Moslem Mohammadi, Noushin Mohammadifard, Mousa Mohammadnia-Afrouzi, Mohammed A Mohammed, Shafiu Mohammed, Murali B V Mohan, Viswanathan Mohan, Farnam Mohebi, Modhurima Moitra, Ali H Mokdad, Mariam Molokhia, Lorenzo Monasta, Julio Cesar Montañez, Mahmood Moosazadeh, Ghobad Moradi, Mahmoudreza Moradi, Maziar Moradi-Lakeh, Mehdi Moradinazar, Paula Moraga, Lidia Morawska, Joana Morgado-da-Costa, Naho Morisaki, Shane Douglas Morrison, Abbas Mosapour, Marilita M Moschos, W Cliff Mountjoy-Venning, Simin Mouodi, Seyyed Meysam Mousavi, Acheneff Asmamaw Muche, Kindie Fentahun Muchie, Ulrich Otto Mueller, Oumer Sada S Muhammed, Satinath Mukhopadhyay, Erin C Mullany, Kate Muller, John Everett Mumford, Manoj Murhekar, G V S Murthy, Srinivas Murthy, Jonah Musa, Kamarul Imran Musa, Ghulam Mustafa, Saravanan Muthupandian, Ashraf F Nabhan, Jean B Nachega, Ahamarshan Jayaraman Nagarajan, Gabriele Nagel,

Mohsen Naghavi, Aliya Naheed, Azin Nahvijou, Kovin Naidoo, Gurudatta Naik, Nitish Naik, Farid Najafi, Luigi Naldi, Hae Sung Nam, Vinay Nangia, Jobert Richie Nansseu, Bruno Ramos Nascimento, Haseeb Nawaz, Nahid Neamati, Ionut Negoii, Ruxandra Irina Negoii, Subas Neupane, Charles Richard James Newton, Frida N Ngalesoni, Josephine W Ngunjiri, Anh Nguyen, Grant Nguyen, Ha Nguyen, Huong Lan Thi Nguyen, Huong Thanh Nguyen, Minh Nguyen, Emma Nichols, Solomon Gedlu Nigatu, Dina Nur Anggraini Ningrum, Yirga Legesse Nirayo, Muhammad Imran Nisar, Molly R Nixon, Nomonde Noluthungu, Marika Nomura, Ole F Norheim, Mehdi Noroozi, Bo Norrving, Jean Jacques Noubiap, Hamid Reza Nouri, Malihe Nourollahpour Shiadeh, Mohammad Reza Nowroozi, Peter S Nyasulu, Carla Makhlof Obermeyer, Richard Ofori-Asenso, Okechukwu Samuel Ogah, Felix Akpojene Ogbo, In-Hwan Oh, Anselm Okoro, Kelechi E Oladimeji, Olanrewaju Oladimeji, Andrew T Olagunju, Tinuke O Olagunju, Pedro R Olivares, Helen Elizabeth Olsen, Bolajoko Olubukunola Olusanya, Jacob Olusegun Olusanya, Kanyin L Ong, Sok King Ong, Anu Mary Oommen, John Nelson Opio, Eyal Oren, Andrei Oros, Doris D V Ortega-Altamirano, Alberto Ortiz, Justin R Ortiz, Eduardo Ortiz-Panozo, Erika Ota, Stanislav S Otstavnov, Mayowa Ojo Owolabi, Mahesh P A, Smita Pakhale, Abhijit P Pakhare, Wen-Harn Pan, Adrian Pana, Basant Kumar Panda, Songhomitra Panda-Jonas, Jeyaraj Durai Pandian, Nikolaos Papantoniou, Eun-Keek Park, Charles D H Parry, Hadi Parsian, Shanti Patel, Sanghamitra Pati, Ajay Patle, George C Patton, Vishnupriya Rao Paturi, Deepak Paudel, Katherine R Paulson, Neil Pearce, Emmanuel K Peprah, David M Pereira, Norberto Perico, Aslam Pervaiz, Konrad Pesudovs, William A Petri, Max Petzold, Michael R Phillips, David M Pigott, Julian David Pillay, Meghdad Pirsaeheb, Martin Pletcher, Constance Dimity Pond, Maarten J Postma, Akram Pourshams, Hossein Poustchi, Dorairaj Prabhakaran, Swayam Prakash, Narayan Prasad, Caroline A Purcell, Manita Pyakurel, Mostafa Qorbani, Reginald Quansah, Amir Radfar, Anwar Rafay, Alireza Rafiei, Fakher Rahim, Kazem Rahimi, Afarin Rahimi-Movaghar, Vafa Rahimi-Movaghar, Mahfuzar Rahman, Md Shafiqur Rahman, Mohammad Hifz Ur Rahman, Muhammad Aziz Rahman, Sajjad ur Rahman, Rajesh Kumar Rai, Fatemeh Rajati, Sasa Rajsic, Usha Ram, Saleem M Rana, Chhabi Lal Ranabhat, Prabhat Ranjan, Davide Rasella, David Laith Rawaf, Salman Rawaf, Christian Razo-García, K Srinath Reddy, Robert C Reiner, Cesar Reis, Marissa B Reitsma, Giuseppe Remuzzi, Andre M N Renzaho, Serge Resnikoff, Luz Myriam Reynales-Shigematsu, Satar Rezaei, Shahab Rezaeian, Mohammad Sadeq Rezaei, Seyed Mohammad Riahi, Antonio Luiz P Ribeiro, Maria Jesus Rios-Blancas, Kedir Teji Roba, Nicholas L S Roberts, Leonardo Roever, Luca Ronfani, Gholamreza Roshandel, Ali Rostami, Gregory A Roth, Ambuj Roy, Enrico Rubagotti, George Mugambage Ruhago, Yogesh Damodar Sabde, Perminder S Sachdev, Basema Saddik, Ehsan Sadeghi, Hosein Safari, Yahya Safari, Roya Safari-Faramani, Mahdi Saffarian, Sare Safi, Saeid Safiri, Rajesh Sagar, Amirhossein Sahebkar, Mohammad Ali Sahraian, Haniye Sadat Sajadi, Nasir Salam, Joseph S Salama, Payman Salamati, Raphael de Freitas Saldanha, Zikria Saleem, Yahya Salimi, Hamideh Salimzadeh, Joshua A Salomon, Sundeep Santosh Salvi, Inbal Salz, Evanson Zondani Sambala, Abdallah M Samy, Juan Sanabria, Maria Dolores Sanchez-Niño, Itamar S Santos, Milena M Santric Milicevic, Bruno Piaszi Sao Jose, Mayank Sardana, Abdur Razzaque Sarker, Nizal Sarrafzadegan, Benn Sartorius, Shahabeddin Sarvi, Brijesh Sathian, Maheswar Satpathy, Miloje Savic, Arundhati R Sawant, Monika Sawhney, Sonia Saxena, Mete Saylan, Mehdi Sayyah, Elke Schaeffner, Maria Inês Schmidt, Ione J C Schneider, Ben Schöttker, Aletta Elisabeth Schutte, David C Schwebel, Falk Schwendicke, Soraya Seedat, Mario Sekerija, Sadaf G Sepanlou, Edson Serván-Mori, Seyedmojtaba Seyedmousavi, Hosein Shabaninejad, Katya Anne Shackelford, Azadeh Shafieesabet, Amira S Shaheen, Masood Ali Shaikh, Mehran Shams-Beyranvand, Mohammad Bagher Shamsi, Morteza Shamsizadeh, Heidar Sharafi, Kiomars Sharafi, Mehdi Sharif, Mahdi Sharif-Alhoseini, Jayendra Sharma, Rajesh Sharma, Sharad Kumar Sharma, Jun She, Aziz Sheikh, Muki Shehu Shey, Peilin Shi, Kenji Shibuya, Chloe Shields,

Girma Temam Shifa, Mekonnen Sisay Shiferaw, Mika Shigematsu, Rahman Shiri, Reza Shirkoobi, Shreya Shirude, Kawkab Shishani, Ivy Shiue, Farhad Shokraneh, Haitham Shoman, Mark G Shrimme, Sharvari Rahul Shukla, Si Si, Soraya Siabani, Abla Mehio Sibai, Tariq J Siddiqi, Inga Dora Sigfusdottir, Naris Silpakit, Diego Augusto Santos Silva, João Pedro Silva, Natacha Torres da Silva, Dayane Gabriele Alves Silveira, Jasvinder A Singh, Narinder Pal Singh, Om Prakash Singh, Prashant Kumar Singh, Virendra Singh, Dharendra Narain Sinha, Eirini Skiadaresi, Karen Sliwa, Amanda E Smith, Mari Smith, Aduauto Martins Soares Filho, Badr Hasan Sobaihi, Soheila Sobhani, Michael Soljak, Moslem Soofi, Masoud Soosaraei, Reed J D Sorensen, Joan B Soriano, Sergey Soshnikov, Ireneous N Soyiri, Angela Spinelli, Luciano A Sposato, Chandrashekhar T Sreeramareddy, Raghavendra Guru Srinivasan, Vinay Srinivasan, Jeffrey D Stanaway, Vladimir I Starodubov, Vasiliki Stathopoulou, Nadine Steckling, Dan J Stein, Leo G Stewart, Leo Stockfelt, Mark A Stokes, Kurt Straif, Agus Sudaryanto, Mu'awiyah Babale Sufiyan, Bruno F Sunguya, Patrick John Sur, Ipsita Sutradhar, Bryan L Sykes, P N Sylaja, Dillon O Sylte, Cassandra E I Szoeki, Rafael Tabarés-Seisdedos, Takahiro Tabuchi, Santosh Kumar Tadakamadla, Koku Sisay Tamirat, Nikhil Tandon, Frank C Tanser, Aberash Abay Tassew, Segen Gebremeskel Tassew, Mohammad Tavakkoli, Nuno Taveira, Nega Yimer Tawye, Arash Tehrani-Banihashemi, Tigist Gashaw Tekalign, Merhawi Gebremedhin Tekle, Habtamu Temesgen, Mohamad-Hani Temsah, Omar Temsah, Abdullah Sulieman Terkawi, Manaye Yihune Teshale, Destaw Fetene Teshome, Belay Tessema, Mebrahtu Teweldemedhin, Jarnail Singh Thakur, Kavumpurathu Raman Thankappan, Andrew Theis, Sathish Thirunavukkarasu, Laura Anne Thomas, Nihal Thomas, Alan J Thomson, Amanda G Thrift, Binyam Tilahun, Quyen G To, Ruoyan Tobe-Gai, Marcello Tonelli, Roman Topor-Madry, Anna E Torre, Miguel Tortajada-Girbés, Marcos Roberto Tovani-Palome, Jeffrey A Towbin, Bach Xuan Tran, Khanh Bao Tran, Tung Thanh Tran, Srikanth Prasad Tripathy, Christopher E Troeger, Thomas Clement Truelsen, Afewerki Gebremeskel Tsadik, Lorainne Tudor Car, E Murat Tuzcu, Hayley D Tymeson, Kingsley N Ukwaja, Irfan Ullah, Rachel L Updike, Muhammad Shariq Usman, Olalekan A Uthman, Muthiah Vaduganathan, Afsane Vaezi, Gaurang Vaidya, Pascual R Valdez, Aaron van Donkelaar, Elena Varavikova, Tommi Juhani Vasankari, Narayanaswamy Venketasubramanian, Ramesh Vidavalur, Santos Villafaina, Francesco S Violante, Sergey Konstantinovich Vladimirov, Vasily Vlassov, Sebastian Vollmer, Steinh Emil Vollset, Theo Vos, Kia Vosoughi, Isidora S Vujcic, Gregory R Wagner, Fasil Shiferaw Wagnew, Yasir Waheed, Judd L Watson, Yanping Wang, Yuan-Pang Wang, Molla Mesele Wassie, Elisabete Weiderpass, Robert G Weintraub, Jordan Weiss, Fitsum Weldegebreal, Kidu Gidey Weldegewrgs, Andrea Werdecker, Adhena Ayaliew Werkneh, T Eoin West, Ronny Westerman, Joanna L Whisnant, Harvey A Whiteford, Justyna Widecka, Katarzyna Widecka, Tissa Wijeratne, Lauren B Wilner, Andrea Sylvia Winkler, Alison B Wiyeh, Charles Shey Wiysonge, Haileab Fekadu Wolde, Charles D A Wolfe, Shouling Wu, Denis Xavier, Gelin Xu, Rixing Xu, Ali Yadollahpour, Seyed Hossein Yahyazadeh Jabbari, Bereket Yakob, Tomohide Yamada, Lijing L Yan, Yuichiro Yano, Mehdi Yaseri, Yasin Jemal Yasin, Pengpeng Ye, Jamal A Yearwood, Alex Yeshaneh, Ebrahim M Yimer, Paul Yip, Biruck Desalegn Yirsaw, Engida Yisma, Naohiro Yonemoto, Gerald Yonga, Seok-Jun Yoon, Marcel Yotebieng, Mustafa Z Younis, Mahmoud Youseffard, Chuanhua Yu, Sojib Bin Zaman, Mohammad Zamani, Zohreh Zare, Luis Zavala-Arciniega, Desalegn Tegabu Zegeye, Elias Asfaw Zegeye, Ayalew Jejaw Zeleke, Kazem Zendehtdel, Taddese Alemu Zerfu, Anthony Lin Zhang, Xueying Zhang, Maigeng Zhou, Jun Zhu, Stephanie R M Zimsen, Sanjay Zodpey, Leo Zocckler, Inbar Zucker, Liesel Joanna J Zuhlke, Stephen S Lim, Christopher J L Murray.

#### Affiliations

Institute for Health Metrics and Evaluation (Prof R Lozano MD, N Fullman MPH, A Afshin MD, T Alam MPH, C A Allen BA, J A Anderson BS, C M Barthelémy MPH, G J Bertolacci BS,

M H Biehl MPH, Prof M Brauer DSc, P S Briant BS, C S Callender BS, A Carter MPH, K Causey BS, K M Cercey BS, J Chalek BS, A J Cohen DSc, L Cornaby BS, E A Cromwell PhD, M Cunningham MSc, Prof L Dandona MD, Prof R Dandona PhD, Prof L Degenhardt PhD, S Deiparine BA, S D Dharmaratne MD, D Dicker BS, D Douwes-Schultz BS, E Eldrenkamp BA, K Estep MPA, Prof Prof V L Feigin PhD, R Feldman BS, S Finegold BS, C Fitzmaurice MD, K J Foreman PhD, T D Frank BS, K Fukutaki BA, J E Fuller MLIS, Prof E Gakidou PhD, W M Gardner AB, E M Goldberg MPH, T M Gorman BS, M G Griswold MA, C N Hawley MSPH, Prof S I Hay FMedSci, Y He MS, T Hsiao BS, C K Huynh BA, C T Ikeda BS, C M S Irvine BS, Prof M Jakovljevic PhD, S L James MD, C O Johnson PhD, S C Johnson MSc, N J Kassebaum MD, L Kemmer PhD, G R Kemp BA, I A Khalil MD, J Y Kim BS, J M Kocarnik PhD, K J Krohn MPH, X R Kulikoff BA, M J Kutz BS, H H Kyu PhD, Prof H J Larson PhD, K M Lau BS, J R Ledesma BA, J B Lee BS, A T Leever BS, Prof A D Lopez PhD, L R Lucchesi BA, E R Maddison BS, H Manguerra BS, A Marks MA, I Martopullo MPH, A I Millar MPH, M K Miller-Petrie MSc, A T Misganaw PhD, M Moitra MPH, Prof A H Mokdad PhD, W C Mountjoy-Venning BA, E C Mullany BA, K Muller MPH, J Mumford BA, Prof M Naghavi MD, G Nguyen MPH, M Nguyen BS, E Nichols BA, M R Nixon PhD, H E Olsen MA, K L Ong PhD, K R Paulson BS, D M Pigott DPhil, M Pletcher BS, C A Purcell BA, R C Reiner PhD, M B Reitsma BS, N L S Roberts BS, J S Salama MSc, K A Shackelford BA, C Shields BA, S Shirude MPH, N Silpakit BS, A E Smith MPA, M Smith MPA, R J D Sorensen MPH, V Srinivasan BA, J D Stanaway PhD, L G Stewart BS, P J Sur MPH, D O Sylte BA, A Theis BA, A E Torre BS, C E Troeger MPH, H D Tymeson BA, R L Updike BA, Prof S E Vollset DrPH, Prof T Vos PhD, J L Whisnant MPH, Prof H A Whiteford PhD, L B Wilner MPH, R Xu BS, J A Yearwood BS, S R M Zimsen MA, L Zocckler BA, Prof S S Lim PhD, Prof C J L Murray DPhil, Department of Global Health (S Kochhar MD, J R Ortiz MD, R J D Sorensen MPH, Prof J L Watson MD), Department of Health Metrics Sciences (A Afshin MD, E A Cromwell PhD, C El Bcheraoui PhD, Prof S I Hay FMedSci, I A Khalil MD, H H Kyu PhD, Prof S S Lim PhD, Prof R Lozano MD, A T Misganaw PhD, Prof A H Mokdad PhD, Prof C J L Murray DPhil, Prof M Naghavi MD, D M Pigott DPhil, R C Reiner PhD, J D Stanaway PhD, Prof S E Vollset DrPH, Prof T Vos PhD), Department of Medicine (B J McMahon MD, T E West MD), Department of Neurology (R Kalani MD), Department of Surgery (S D Morrison MD), Division of Cardiology (G A Roth MD), Division of Hematology (C Fitzmaurice MD), Division of Plastic Surgery (C S Crowe MD, B B Massenburg MD), University of Washington, Seattle, WA, USA (Prof E Oren PhD, A Oros MA); Center for Health Systems Research (L Avila-Burgos PhD, I Cahuana-Hurtado PhD, Prof I Heredia-Pi DipSocSc, D D V Ortega-Altamirano DrPH, M Rios-Blancas MPH, Prof E Serván-Mori DSc), Center for Nutrition and Health Research (E Denova-Gutiérrez DSc), Center for Population Health Research (Prof E Ortiz-Panozo MD, C Razo-García MSc), Department of International Health and Collaboration (M Nomura PhD), Department of Tobacco Research (L Zavala-Arciniega MSc, I M Reynales-Shigematsu PhD), National Institute of Public Health, Cuernavaca, Mexico (I R Campos-Nonato PhD, J Campuzano Rincon PhD, Prof M Hijar PhD, F Mejia-Rodriguez MSc); Department of Medical Laboratory Science (Z Ataro MSc, F Weldegebreal MPH), Department of Pediatrics (A R Abrham MSc), School of Nursing and Midwifery (T T Dasa MSc, K T Roba PhD), School of Pharmacy (J Abdela MSc, Y Ayele MSc, G Mengistu MSc, M S Shiferaw MSc), School of Public Health (A G Bali MPH, M G Tekle MPH), Haramaya University, Harar, Ethiopia (D Abate MSc, T F Gelano MSc, T Hailegiyorgis MSc, M T Jalu MPH, T G Tekalign MS); College of Health Sciences (B Gebremichael MSc), College of Veterinary Medicine and Agriculture (K Amenu PhD), Department of Pharmacology and Clinical Pharmacy (S M Abay PhD, O S S Muhammed MSc), Department of Preventive Medicine (S Getachew MPH), Department of Psychiatry (W Fekadu PhD), School of Allied Health Sciences (E Yisma MPH), School of Nursing and Midwifery (H A Areri MSc), School of Public Health (N D Abebe MPH, A Berhane PhD, K Deribe PhD,

G T Shifa PhD, Y J Yasin MPH), Addis Ababa University, Addis Ababa, Ethiopia (G T Demoz MSc); Department of Law Philosophy and Economic Studies (C Abbafati PhD), La Sapienza University, Rome, Italy; Brain and Spinal Cord Injury Research Center (Z Khazaiepour MD), Cancer Biology Research Center (R Shirkoohi PhD), Cancer Research Center (A Nahvijou PhD, R Shirkoohi PhD, K Zendeheh PhD), Center of Expertise in Microbiology (Prof S Seyedmousavi PhD), Community-Based Participatory Research Center (Prof R Majdzadeh PhD), Department of Anatomy (S Sobhani MD), Department of Epidemiology and Biostatistics (Prof S Hosseini PhD, M Mansournia PhD, M Yaseri PhD), Department of Health (H Abbastabar PhD), Department of Health Management and Economics (M Anjomshoa PhD, S Mousavi PhD), Department of Pharmacology (A Haj-Mirzaian MD, A Haj-Mirzaian MD), Department of Urology (E Amini MD), Digestive Diseases Research Institute (Prof R Malekzadeh MD, Prof A Pourshams MD, H Poustchi PhD, G Roshandel PhD, H Salimzadeh PhD, S G Sepanlou MD), Endocrinology and Metabolism Research Center (M Afarideh MD, Prof A Esteghamati MD, S Esteghamati MD), Hematologic Malignancies Research Center (A Kasaeian PhD), Hematology-Oncology and Stem Cell Transplantation Research Center (A Kasaeian PhD), Iran National Institute of Health Research (F Mohebi MD, H S Sajadi PhD), Iranian National Center for Addiction Studies (Prof A Rahimi-Movaghar MD), Knowledge Utilization Research Center (Prof R Majdzadeh PhD), Multiple Sclerosis Research Center (S Eskandari PhD, B Mohajer MD, Prof M Sahraian MD), Non-communicable Diseases Research Center (N Abbasi MD, F Farzadfar MD, S N Irvani MD, B Mohajer MD, F Mohebi MD, M Shams-Beyranvand MSc), School of Medicine (N Hafezi-Nejad MD), Sina Trauma and Surgery Research Center (Prof V Rahimi-Movaghar MD, M Safdarian MD, Prof P Salamati MD, M Sharif-Alhoseini PhD), Uro-Oncology Research Center (M Nowroozi MD), Tehran University of Medical Sciences, Tehran, Iran; Department of Epidemiology, Biostatistics, and Occupational Health (H T Ayele PhD), Montreal Neuroimaging Center (N Abbasi MD), Montreal Neurological Institute (S Fereshtehnejad PhD), McGill University, Montreal, QC, Canada; Department of Medical Parasitology (M M Khater MD), Department of Neurology (Prof F Abd-Allah MD, Prof A Abdelalim MD, M I Hegazy PhD), Cairo University, Cairo, Egypt; Department of Oncology (O Abdel-Rahman MD), Department of Medicine (Prof M Tonelli MD), University of Calgary, Calgary, AB, Canada; Department of Entomology (A M Samy PhD), Department of Obstetrics and Gynecology (Prof A F Nabhan PhD), Department of Oncology (O Abdel-Rahman MD), Ain Shams University, Cairo, Egypt; Department of Anesthesiology (A Ahmadi PhD), Department of Environmental Health Engineering (Prof A Almasi PhD), Department of Epidemiology & Biostatistics (Prof F Najafi PhD, Y Salimi PhD), Department of Food Technology & Quality Control (E Sadeghi PhD), Department of Health Education & Promotion (F Rajati PhD), Department of Psychiatry (Prof H Khazaie MD), Department of Traditional and Complementary Medicine (M Farzaei PhD), Department of Urology (Prof M Moradi MD), Environmental Determinants of Health Research Center (S Rezaei PhD, M Soofi PhD), Faculty of Nursing and Midwifery (A Abdi PhD), Faculty of Nutrition and Food Sciences (F Heydarpour PhD), Faculty of Public Health (B Karami Matin PhD, A Kazemi Karyani PhD, R Safari-Faramani PhD), Imam Ali Cardiovascular Research Center (S Siabani PhD), Pharmaceutical Sciences Research Center (M Farzaei PhD), Research Center for Environmental Determinants of Health (M Moradinazar PhD), Sleep Disorders Research Center (M Ghadami MD), Sports Medicine & Rehabilitation (M Shamsi PhD), Kermanshah University of Medical Sciences, Kermanshah, Iran (H Farzani MD, K Ghadiri BEP, S Heydarpour PhD, A Khatony PhD, Prof M Pirsaeheb PhD, S Rezaeian PhD, Y Safari PhD, K Sharafi PhD); Department of Epidemiology (I Abdollahpour PhD), Arak University of Medical Sciences, Arak, Iran; Multiple Sclerosis Research Center, Tehran, Iran (I Abdollahpour PhD); Department of Statistics (R S Abdulkader MD), Manonmanian Sundaranar University, Tirunelveli, India; Department of Clinical Chemistry (B Biadgo MSc), Department of Epidemiology and Biostatistics (H F Wolde MPH), Department of Epidemiology and Biostatistics (T Y Akalu MPH, K S Tamirat MPH, D F Teshome MPH), Department of Medical Microbiology (B Tessema PhD), Department of Medical Parasitology (A J J Zeleke MSc), Human Nutrition Department (Z Abebe MSc), Institute of Public Health (K A Alene MPH, B Bekele MPH, A F Dadi MPH, M A Limenih MSc, M Melku MSc, A A Muche MPH, K Muchie MSc, s G Nigatu MPH, A A Tassew MPH, B Tilahun PhD, M M Wassie MSc), University of Gondar, Gondar, Ethiopia (H W Baynes MSc); College of Health Sciences (G M Kassa MSc), Department of Nursing (A Alebel MSc, G A Dessie MSc, D H Kassa MSc, F S Wagnew MSc), Department of Public Health (Y A Belay MPH, G D Kibret MPH, C T Leshargie MPH), Debre Markos University, Debre Markos, Ethiopia (A N Abejie MPH, H Temesgen MPH); Anatomy Unit (T B Hagos MSc), Biomedical Sciences Division (G B Hailu MSc), Clinical Pharmacy Unit (H N Abraha MSc, T D Kassa MSc, Y L Nirayo MS, K G Weldegewergs MSc), Department of Biostatistics (K Gezae MSc), Department of Environmental Health Science (A A Werkneh MSc), Department of Epidemiology (A G Belay MPH), Department of Microbiology and Immunology (S Muthupandian PhD), Department of Nutrition and Dietetics (M G Degefa BSc, A Kahsay MPH), Institute of Biomedical Science (E T Asfaw MSc), School of Medicine (D T Mengistu MSc), School of Nursing (G Y Abyu PhD), School of Pharmacy (S W Asgedom MSc, H Bitew MSc, A K Gebre MSc, T G Gebremichael MSc, A G Tsadik MSc, E M Yimer MSc), School of Public Health (S F Abera MSc, B M Adhena MPH, A B Belachew MSc, G B Gebregergs MPH), Mekelle University, Mekelle, Ethiopia (B Demtsu MSc, H G Meles MPH, S G Tassew MSc); Institute of Biological Chemistry and Nutrition (S F Abera MSc), University of Hohenheim, Stuttgart, Germany; Department of Health Sciences (E Duken MSc), Department of Medical Laboratory Sciences (O Abil MSc), Wollega University, Nekemte, Ethiopia; School of Public Health (O Abil MSc), University of Medical Science, Ondo, Ondo, Nigeria; Department of Cardiology (Prof V Aboyans MD), Dupuytren University Hospital, Limoges, France; Institute of Epidemiology (Prof V Aboyans MD), University of Limoges, Limoges, France; Department of Healthcare Policy and Research (Prof L J Abu-Raddad PhD), Weill Cornell Medical College in Qatar, Doha, Qatar; Institute of Community and Public Health (N M Abu-Rmeileh PhD), Birzeit University, Birzeit, Palestine; Department of Nursing (G Y Abyu PhD), Department of Psychiatry (W Fekadu PhD, T Mekonen MSc), Department of Public Health Nutrition (N Fentahun PhD), Bahir Dar University, Bahir Dar, Ethiopia (A Amare PhD); Bénin Clinical Research Institute, Cotonou, Benin (M M K Accrombessi PhD, E F A Avokpaho MD); Department of Preventive Medicine (D Acharya MPH), Dongguk University, Gyeongju, South Korea; Department of Community Medicine (D Acharya MPH), Nepalgunj Medical College (M Pyakurel MPH), Kathmandu University, Devdaha, Nepal; Nepal Development Society, Pokhara, Nepal (P Acharya MPH); Department of Global Health (A A Adamu MSc, O O Adetokunboh MD, Prof C S Wiysonge MD), Department of Psychiatry (Prof C D H Parry PhD, Prof S Seedat PhD), Faculty of Medicine & Health Sciences (Prof P S Nyasulu PhD), Stellenbosch University, Cape Town, South Africa; Cochrane South Africa (A A Adamu MSc, O O Adetokunboh MD), Unit for Hypertension and Cardiovascular Disease (Prof A E Schutte PhD), South African Medical Research Council, Cape Town, South Africa (Prof D J Stein MD); Department of Medicine (O S Ogah PhD), Medicine (O M Adebayo MD), University College Hospital, Ibadan, Ibadan, Nigeria; Department of Sociology (I A Adedeji PhD), Olabisi Onabanjo University, Ago-Iwoye, Nigeria; Department of Medical Rehabilitation (Prof R A Adedoyin PhD), Obafemi Awolowo University, Ile-Ife, Nigeria; School of Medicine (V Adekanmbi PhD), Cardiff University, Cardiff, UK; Nepal Health Research Environment (T B Adhikari MPH), Center for Social Science and Public Health Research Nepal, Lalitpur, Nepal; Unit for Health Promotion Research (T B Adhikari MPH), University of Southern Denmark, Esbjerg, Denmark; Emergency Department (M G Adib MD), Saint Mark Hospital, Alexandria, Egypt; Ivorian Association for Family Welfare, Abidjan, Côte d'Ivoire (A K Adou MD); Sport Science Department (J C Adsuar PhD, S Villafaina MSc), University of Extremadura, Badajoz, Spain (D Collado-Mateo MSc); Zabol University of Medical Sciences, Zabol, Iran (M Afshari MD); Department of Family Medicine (G Agarwal MD), Department of Pathology and Molecular

Medicine (T O Olagunju MD), McMaster University, Hamilton, ON, Canada; Department of Zoology (S A Aghayan PhD), Yerevan State University, Yerevan, Armenia; Research Group of Molecular Parasitology (S A Aghayan PhD), Scientific Center of Zoology and Hydroecology, Yerevan, Armenia; Department of Health (D Agius MD), Directorate for Policy (N Azzopardi-Muscat PhD), Directorate for Health Information and Research, Pietà, Malta; Research Area for Informatics and Big Data (Prof A Agrawal PhD), CSIR Institute of Genomics and Integrative Biology, Delhi, India; Department of Internal Medicine (Prof A Agrawal PhD), National School of Tropical Medicine (Prof P J Hotez PhD), Baylor College of Medicine, Houston, TX, USA; Health Promotion Division (M Arora PhD), Indian Institute of Public Health (Prof G V S Murthy MD), Indian Institute of Public Health (Prof S Zodpey PhD), Public Health Foundation of India, Gurugram, India (S Agrawal PhD, A Awasthi PhD, Prof L Dandona MD, Prof R Dandona PhD, G A Kumar PhD, D K Lal MD, M R Mathur PhD, Prof D Prabhakaran DM, K S Reddy DM); Vital Strategies, Gurugram, India (S Agrawal PhD); Department of Neurosurgery (H Safari MD), Department of Public Health (M A Khafaie PhD), Education Development Center (Prof M Sayyah PsyD), Environmental Technologies Research Center (M Ahmadi PhD), Medical Physics Department (A Yadollahpour PhD), Thalassemia and Hemoglobinopathy Research Center (F Rahim PhD), Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran; Cancer Research Center (Prof M Akbari MD), Department of Biostatistics (A Khajavi MSc), Department of Epidemiology (N Izadi MSc, S Riahi PhD), Department of Ophthalmology (H Ahmadi MD), Ophthalmic Epidemiology Research Center (S Safi PhD), Ophthalmic Research Center (H Ahmadi MD, S Safi PhD, M Yaseri PhD), Research Institute for Endocrine Sciences (A Haj-Mirzaian MD, S N Irvani MD), Safety Promotion and Injury Prevention Research Center (N Jahanmehr PhD), School of Public Health (N Jahanmehr PhD), Shahid Beheshti University of Medical Sciences, Tehran, Iran; Department of Environmental Health Sciences and Technology (S Mereta PhD), Department of Epidemiology (M B Ahmed MPH, T T Gebrehiwot MPH), Department of Health Education & Behavioral Sciences (G T Feyissa MPH), Department of Population and Family Health (A T Gebremedhin MPH), Mycobacteriology Research Center (E Duken MSc), School of Pharmacy (E M Bobasa MSc), Jimma University, Jimma, Ethiopia; Health Economics and Financing Research Group (A R Sarker MSS), Health Systems and Population Studies Division (S Ahmed MSc), Initiative for Non Communicable Diseases (A Naheed PhD), Maternal and Child Health Division (S Zaman MPH), International Centre for Diarrhoeal Disease Research, Bangladesh (icddr), Dhaka, Bangladesh; Department of Learning, Informatics, Management, and Ethics (S Ahmed MSc), Department of Medical Epidemiology and Biostatistics (J J Carrero PhD, Prof E Weiderpass PhD), Department of Medicine Huddinge (Prof A Moghadamnia PhD), Department of Neurobiology (Prof J Årnlöv PhD), Department of Neurobiology, Care Sciences and Society (S Fereshtehnejad PhD), Department of Public Health Sciences (Prof P Allebeck MD, Z El-Khatib PhD), Karolinska Institutet, Stockholm, Sweden; Department of Civil and Environmental Engineering (A S Akanda PhD), University of Rhode Island, Kingston, RI, USA; Department of Midwifery (M Akibu MSc, M T Dimberu MA), Department of Public Health (M G Ansha MPH, T Kolola MPH), Debre Berhan University, Debre Berhan, Ethiopia; Institute for Advanced Medical Research and Training (R O Akinyemi PhD, Prof M O Owolabi DrM), University of Ibadan, Ibadan, Nigeria; Department of Epidemiology (T Akinyemiju PhD), University of Kentucky, Lexington, KY, USA; Department of Nutritional Sciences (A Badawi PhD), The Centre for Global Child Health, Hospital for Sick Children (Prof Z A Bhutta PhD), The Hospital for Sick Children (N Akseer PhD), University of Toronto, Toronto, ON, Canada; Evidence Based Practice Center (F Alahdab MD), Mayo Clinic Foundation for Medical Education and Research, Rochester, MN, USA; Research Committee (F Alahdab MD), Syrian American Medical Society, Washington, DC, USA; Internal Medicine Department (Z Al-Aly MD), Washington University in St Louis, St Louis, MO, USA; Clinical Epidemiology Center, VA St Louis Health Care System (Z Al-Aly MD), Department of Internal Medicine (S K Jassal MD), Department of Veterans Affairs, St Louis, MO, USA; Department of Computer Science and Software Engineering (Prof G J Milne PhD), School of Medicine (Prof G J Hankey MD), School of Population and Global Health (K Alam PhD), University of Western Australia, Perth, WA, Australia; Nab'a Al-Hayat Foundation for Medical Sciences and Health Care, Najaf, Iraq (A Albujeer DDS); National Centre for Epidemiology and Population Health (M Bin Sayeed MSPS), Research School of Population Health (K A Alene MPH), Australian National University, Canberra, ACT, Australia; Department of Family and Community Medicine (A A Jamal MD), Department of Pediatrics (B H Sobaih MD, M Temsah MD), Pediatric Intensive Care Unit (A Al-Eyadhy MD), King Saud University, Riyadh, Saudi Arabia (K Altirkawi MD); King Abdullah Bin Abdulaziz University Hospital, Riyadh, Saudi Arabia (Prof S Alhabib PhD); Public Health Research Center (R Ali MPH), New York University Abu Dhabi, Abu Dhabi, United Arab Emirates; Centre for Tropical Medicine and Global Health, Nuffield Department of Medicine (Prof P W Gething PhD, S Lewycka PhD), Department of Psychiatry (Prof C R J Newton MD), Nuffield Department of Population Health (R Ali MPH, D A Bennett PhD), Nuffield Department of Women's and Reproductive Health (Prof K Rahimi MD), University of Oxford, Oxford, UK (Prof V Jha MD); Qazvin University of Medical Sciences, Qazvin, Iran (M Alijanzadeh PhD); Department of Immunology (Prof A Rafiei PhD), Department of Medical Mycology (H Badali PhD), Department of Medical Mycology and Parasitology (A Vaezi PhD), Department of Neurology (N Karimi MD), Department of Pediatrics (M Rezai MD), Department of Physiology and Pharmacology (M Mohammadi PhD), Gastrointestinal Cancer Research Center (R Alizadeh-Navaei PhD), Health Sciences Research Center (M Moosazadeh PhD), Immunogenetics Research Center (N Karimi MD), Molecular and Cell Biology Research Center (Prof A Rafiei PhD), School of Public Health (Prof A Enayati PhD), Toxoplasmosis Research Center (Prof A Daryani PhD, S Sarvi PhD), Mazandaran University of Medical Sciences, Sari, Iran (M Fakhar PhD, A Hedayatzadeh-Omran PhD, M Nourollahpour Shiadeh PhD, Z Zare PhD); Department of Health Policy and Management (Prof S M Aljunid PhD), Kuwait University, Safat, Kuwait; International Centre for Casemix and Clinical Coding (Prof S M Aljunid PhD), National University of Malaysia, Bandar Tun Razak, Malaysia; Department of Population Health (A Alkerwi PhD), Luxembourg Institute of Health, Strassen, Luxembourg; University of Bordeaux, Bordeaux, France (Prof F Alla PhD); Swedish Research Council for Health, Working Life, and Welfare, Stockholm, Sweden (Prof P Allebeck MD); United Arab Emirates University, Al Ain, United Arab Emirates (Prof F Al-Maskari PhD); Psychiatric Hospital Ain Abessa Setif, Ain Abessa, Algeria (Prof F Al-Maskari PhD); Medical Research Center (H M Al-Mekhlafi PhD), Jazan University, Jazan, Saudi Arabia (Prof N Bedi MD); Department of Medical Parasitology (H M Al-Mekhlafi PhD), Sana'a University, Sana'a, Yemen; Research Program in Epidemiology & Public Health (Prof J Alonso MD), Hospital del Mar Medical Research Institute, Barcelona, Spain; Department of Experimental and Health Sciences (Prof J Alonso MD), Pompeu Fabra University, Barcelona, Spain; Department of Family and Community Medicine (Prof R M Al-Raddadi PhD), King Abdulaziz University, Jeddah, Saudi Arabia; Department of Operative and Preventive Dentistry (Prof F Schwendicke MPH), Institute of Public Health (Prof R Busse PhD, Prof E Schaeffner MD), Charité University Medical Center Berlin, Berlin, Germany (U Alsharif MD); Research Group on Health Economics (Prof N Alvis-Guzman PhD), University of Cartagena, Cartagena, Colombia; Research Group in Hospital Management and Health Policies (Prof N Alvis-Guzman PhD), University of the Coast, Barranquilla, Colombia; Sansom Institute (A Amare PhD), Wardliparingga Aboriginal Research Unit (P S Azzopardi PhD), South Australian Health and Medical Research Institute, Adelaide, SA, Australia; Department of Diseases and Noncommunicable Diseases and Health Promotion (A M Soares Filho DSc), Department of the Health Industrial Complex and Innovation in Health (Prof D A Silveira MSc), Policy and Planning Directorate (D T Zegeye MPH), Federal Ministry of Health, Beirut, Lebanon (Prof W Ammar PhD); Center for Research on Population and Health (Prof C M Obermeyer DSc), Department of Epidemiology and Population Health (Prof A M Sibai PhD), Faculty of Health Sciences (Prof W Ammar PhD), American University of Beirut,

Beirut, Lebanon; Faculty of Medicine (N H Anber PhD), Mansoura University, Mansoura, Egypt (N H Anber PhD); Anatomy and Embryology Department (R I Negoi PhD), Department of General Surgery (D V Davitoui PhD, M Hostiuic PhD), Department of Legal Medicine and Bioethics (S Hostiuic PhD), Emergency Hospital of Bucharest (Prof M Beuran PhD, I Negoi PhD), Carol Davila University of Medicine and Pharmacy, Bucharest, Romania (C Andrei PhD); Department of Medicine (S Androudi PhD), University of Thessaly, Volos, Greece; Department of Public Health (Y C D Geramo MSc, G T Shifa PhD, M Y Teshale MPH), Arba Minch University, Arba Minch, Ethiopia (M D Animut MPH); Zahedan University of Medical Sciences, Zahedan, Iran (H Ansari PhD); School of Public Health (A Ansariadi PhD), Hasanuddin University, Makassar, Indonesia; Department of Health Policy and Administration (C T Antonio MD), Development and Communication Studies (E K Macarayan PhD), University of the Philippines Manila, Manila, Philippines; Independent Consultant, Kabul, Afghanistan (P Anwari MSc); Department of Internal Medicine (L T Appiah MD), Komfo Anokye Teaching Hospital, Adum, Ghana; School of Medical Sciences (L T Appiah MD), Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; School of Health Sciences (O Aremu PhD), Birmingham City University, Birmingham, UK; School of Health and Social Studies (Prof J Årnlöv PhD), Dalarna University, Falun, Sweden; Research, Health Related Information Dissemination Amongst Youth, New Delhi, India (M Arora PhD); Monitoring Evaluation and Operational Research Project (K K Aryal PhD), Abt Associates Nepal, Lalitpur, Nepal; Qom University of Medical Sciences, Qom, Iran (H Asayesh MSc); South Asian Public Health Forum, Lahore, Pakistan (R J Asghar MPH); Department of Medical Biotechnology (A Sahebkar PhD), Education Development Center (R Assadi PhD), Mashhad University of Medical Sciences, Mashhad, Iran; University Institute of Public Health (S Atique PhD), The University of Lahore, Lahore, Pakistan; Public Health Department (S Atique PhD), University of Hail, Hail, Saudi Arabia; Berman Institute of Bioethics (Prof J Fanzo PhD), Center for Clinical Global Health Education (S R Atre PhD), Department of Epidemiology (Prof J B Nachega PhD), Department of Gastrointestinal and Hepatology (K Vosoughi MD), Department of Health Policy and Management (A T Khoja MD), Department of International Health (M N Kosek MD), Department of Radiology (N Hafezi-Nejad MD, A Haj-Mirzaian MD), Johns Hopkins University, Baltimore, MD, USA; D Y Patil Medical College (S R Atre PhD), D Y Patil Vidyapeeth, Pune, India (A R Sawant MD); Department of Social Welfare (M S Atteraya PhD), Keimyung University, Daegu, South Korea; Department of Health Sciences (Prof T Brugha MD), School of Business (Prof M Ausloos PhD), University of Leicester, Leicester, UK; Contrôle des Maladies Infectieuses (E F A Avokpaho MD), Non-communicable Disease Department (F G Gankpe MD), Laboratory of Studies and Research-Action in Health, Porto Novo, Benin; Indian Institute of Public Health, Gandhinagar, India (A Awasthi PhD); Austin Clinical School of Nursing (M Rahman PhD), Department of Psychology (Prof T Wijeratne MD), School of Nursing and Midwifery (Prof D Edvardsson PhD), The Judith Lumley Centre (B Ayala Quintanilla PhD), La Trobe University, Melbourne, VIC, Australia; General Office for Research and Technological Transfer (B Ayala Quintanilla PhD), Peruvian National Institute of Health, Lima, Peru; Public Health Department (H T Ayele PhD, T A Zerfu PhD), Dilla University, Dilla, Ethiopia; Department of Community and Global Health (R Ayer MHS), Department of Diabetes and Metabolic Diseases (T Yamada MD), Department of Global Health Policy (M Rahman MHS, Prof K Shibuya MD), Department of Mental Health (Prof N Kawakami PhD), University of Tokyo, Tokyo, Japan; Clinical Neurological Sciences (L A Sposato MD), Department of Clinical Neurological Sciences (V Hachinski DSc), The University of Western Ontario, London, ON, Canada (M Azarpazhooh MD); Global Adolescent Health Group (P S Azzopardi PhD), Burnet Institute, Melbourne, VIC, Australia; Department of Health Services (N Azzopardi-Muscat PhD), University of Malta, Msida, Malta; Department of Public Health Medicine (T K Babalola MSc, T P Mashamba-Thompson PhD, Prof K Naidoo PhD, K E Oladimeji MPH, Prof B Sartorius PhD), University of KwaZulu-Natal, Durban, South Africa (Prof F C Tanser PhD); Department of Community Health

and Primary Care (T K Babalola MSc), Department of Psychiatry (A T Olagunju MD), University of Lagos, Lagos, Nigeria; Center for Infectious Diseases Research, Babol, Iran (A Babazadeh MD, S Ebrahimpour PhD); Health Promotion and Chronic Disease Prevention Branch (J J Lang PhD), Public Health Sciences Division (A Badawi PhD), Public Health Agency of Canada, Toronto, ON, Canada; Department of Environmental Health Engineering (Prof K Balakrishnan PhD), Sri Ramachandra Medical College and Research Institute, Chennai, India; Department of Hypertension (Prof M Banach PhD), Medical University of Lodz, Lodz, Poland; Polish Mothers' Memorial Hospital Research Institute, Lodz, Poland (Prof M Banach PhD); Department of Epidemiology and Public Health (Prof M Kivimäki PhD, M R Mathur PhD), Department of Health Informatics (S Chung PhD), Department of Psychology (M Kumar PhD), Ear Institute (Prof A C Davis PhD), Institute for Global Health (H Haghparast Bidgoli PhD), Institute of Health Informatics (A Banerjee PhD), The UCL Centre for Global Health Economics (C Birungi MSc), University College London, London, UK; Faculty of Medicine (J A M Banoub MD), Alexandria University, Alexandria, Egypt; Department of Transplant Services (J A M Banoub MD), University Hospital Foundation Santa Fe de Bogotá, Bogotá, Colombia; Department of Research (A Banstola MPH), Public Health Perspective Nepal, Pokhara-Lehknath Metropolitan City, Nepal; Clinic for Infectious and Tropical Diseases (A Barac PhD), Clinical Center of Serbia, Belgrade, Serbia; Centre School of Public Health and Health Management (Prof M M Santric Milicevic PhD), Faculty of Medicine (A Barac PhD, E Dubljanin PhD), Faculty of Medicine Institute of Epidemiology (I S Vujcic PhD), University of Belgrade, Belgrade, Serbia; Area de Estadística, Dirección Actuarial (Prof J Castillo Rivas MSc), Department of Neurosciences (Prof M A Barboza MD), Costa Rican Department of Social Security, San Jose, Costa Rica; School of Dentistry (Prof J Castillo Rivas MSc), School of Medicine (Prof M A Barboza MD), University of Costa Rica, San Pedro, Costa Rica; Molecular Medicine and Pathology (K B Tran MD), School of Psychology (Prof S L Barker-Collo PhD), University of Auckland, Auckland, New Zealand; Augenpraxis Jonas (S Panda-Jonas MD), Department of Ophthalmology (Prof J B Jonas MD), Institute of Public Health (Prof T W Bärnighausen MD, Prof J De Neve MD, B Moazen MSc, S Mohammed PhD), Heidelberg University, Heidelberg, Germany; Ariadne Labs (E K Macarayan PhD), Department of Environmental Health (G R Wagner MD), Department of Global Health and Population (Prof T W Bärnighausen MD, A B Feigl PhD, Prof O F Norheim PhD, Prof S Vollmer PhD), Department of Global Health and Social Medicine (G Bukhman MD), Department of Nutrition (E L Ding DSc, M S Farvid PhD), Division of General Internal Medicine and Primary Care (Prof A Sheikh MD), Heart and Vascular Center (M Vaduganathan MD), T H Chan School of Public Health (P C Gupta DSc), Harvard University, Boston, MA, USA (M G Shrimme MD, B Yakob PhD); Department of Industrial Engineering (Prof L H Barrero DSc), Pontifical Javeriana University, Bogota, Colombia; Barcelona Institute for Global Health (Prof Q Bassat MD), Tuberculosis Department (A L Garcia-Basteiro MD), Barcelona Institute for Global Health, Barcelona, Spain (Prof J V Lazarus PhD); Tuberculosis (A L Garcia-Basteiro MD), Manhiça Health Research Center, Manhiça, Mozambique (Prof Q Bassat MD); School of Health Sciences (A Basu PhD), University of Canterbury, Christchurch, New Zealand; Center for Health Policy & Center for Primary Care and Outcomes Research (Prof J A Salomon PhD), Department of Medicine (S Basu PhD), Stanford University, Palo Alto, CA, USA; Doctor Evidence, Santa Monica, CA, USA (R J Battista MBA, M Fazeli PhD); Melbourne Medical School, Melbourne, VIC, Australia (Prof B T Baune PhD); Department of Psychiatry (Prof S Bazargan-Hejazi BEP), Charles R Drew University of Medicine and Science, Los Angeles, CA, USA; Department of Psychiatry and Biobehavioral Sciences (Prof S Bazargan-Hejazi BEP), University of California Los Angeles, Los Angeles, CA, USA; Department of Community Medicine (Prof N Bedi MD), Gandhi Medical College Bhopal, Bhopal, India; Department of Environmental Health Science (S Gallus DSc), Department of Neuroscience (E Beghi MD, G Giussani PhD), Department of Oncology (M Cortinovis PhD), Department of Renal Medicine (B Bikbov MD, N Perico MD), Mario Negri Institute for

Pharmacological Research, Milan, Italy (Prof G Remuzzi MD); Air Pollution Research Center (B Heibati PhD), Department of Community Medicine (A Tehrani-Banihashemi PhD), Department of Health Policy (H Shabanejad PhD), Department of Neuroscience (M Safdarian MD), Health Management and Economics Research Center (M Behzadifar PhD), Physiology Research Center (M Yousefifard PhD), Preventive Medicine and Public Health Research Center (M Moradi-Lakeh MD, A Tehrani-Banihashemi PhD, K Vosoughi MD), Iran University of Medical Sciences, Tehran, Iran (T Beyranvand PhD, F Farhadi MD); Social Determinants of Health Research Center (M Behzadifar PhD), Lorestan University of Medical Sciences, Khorramabad, Iran (M Behzadifar MS); Department of Neurology (Prof Y Béjot PhD), University Hospital of Dijon, Dijon, France; Dijon Stroke Registry - UFR Sciences Santé (Prof Y Béjot PhD), University of Burgundy, Dijon, France; Public Health Department (B Bekele MPH, H Y Hassen MPH), Mizan-Tepi University, Teppi, Ethiopia (A Henok MPH); Tewelde Legesse Health Sciences College, Mekelle, Ethiopia (S A Belay MPH); Department of Ophthalmology and Visual Science (Prof J J Huang MD), School of Forestry and Environmental Studies (Prof M L Bell PhD), Yale University, New Haven, CT, USA; Department of Medicine (A K Bello PhD), University of Alberta, Edmonton, AB, Canada; Center for Clinical and Epidemiological Research (A C Goulart PhD), Department of Biomechanics (L G Mandarano-Filho PhD), Department of Internal Medicine (I M Bensenor PhD, Prof I S Santos PhD), Department of Medicine (Prof P A Lotufo DrPH), Department of Pathology and Legal Medicine (M R Tovani-Palome MSc), Department of Psychiatry (Y Wang PhD), Division of Ophthalmology (J M Furtado MD), University Hospital, Internal Medicine Department (A C Goulart PhD), University of São Paulo, São Paulo, Brazil; Langone Medical Center (A Shafieesabet MD), WHO Collaborating Center (H Benziar PhD), New York University, New York, NY, USA; Adigrat University, Adigrat, Ethiopia (A K Berhe MSc); School of Public Health (A K Berhe MSc), Wolaita Sodo University, Addis Ababa, Ethiopia; Division of Cardiology (Prof A E Berman MD), Medical College of Georgia at Augusta University, Augusta, GA, USA; Department of Health Policy (Prof A E Berman MD), Personal Social Services Research Unit (R Kadel MPH), London School of Economics and Political Science, London, UK; Dental Institute (E Bernabe PhD), Division of Patient and Population (Prof W Marcenes PhD), Faculty of Life Sciences and Medicine (Prof P I Dargan MB, M Molokhia PhD), School of Population Health & Environmental Sciences (Prof C D A Wolfe MD), King's College London, London, UK; Hubert Department of Global Health (R S Bernstein MD), Rollins School of Public Health (Prof Y Liu PhD), Emory University, Atlanta, GA, USA; Department of Global Health (R S Bernstein MD), University of South Florida, Tampa, FL, USA; Institutes of Applied Health Research and Translational Medicine (N Bhala DPhil), Queen Elizabeth Hospital Birmingham, Birmingham, UK; IAHR/ITM (N Bhala DPhil), University of Birmingham, Birmingham, UK; Department of Internal Medicine (Prof A Bhalla MD, D P Lad DM), Department of Pediatrics (S D Lad MD), School of Public Health (Prof J S Thakur MD, Prof J S Thakur MD), Post Graduate Institute of Medical Education and Research, Chandigarh, India (Prof A Bhansali MD); Centre for Global Chronic Conditions (M Karanikolos MPH), Department of Disease Control (J Cano PhD), Department of Health Services Research and Policy (Prof M McKee DSc), Department of Infectious Disease Epidemiology (Prof H J Larson PhD), Department of Medical Statistics (Prof N Pearce PhD), Department of Non-communicable Disease Epidemiology (Prof S Kinra PhD, Prof D Prabhakaran DM), London School of Hygiene & Tropical Medicine, London, UK (S Bhattarai MD); Nepal Academy of Science & Technology, Patan, Nepal (S Bhattarai MD); Injury Division (Prof R Q Ivers PhD), The George Institute for Global Health, New Delhi, India (S Bhaumik MBBS, Prof V Jha MD, P K Maulik PhD); Center of Excellence in Women and Child Health (Prof Z A Bhutta PhD), Department of Pediatrics & Child Health (M Nisar MSc), Aga Khan University, Karachi, Pakistan; Cellular and Molecular Biology Research Center (H Nouri PhD), Department of Clinical Biochemistry (A Mosapour PhD), N Neamati MSc, H Parsian PhD), Department of Immunology (M Mohammadnia-Afrouzi PhD), Fatemeh Zahra Infertility and Reproductive Health Center (P Mirabi PhD), Health Research Institute (R Ghadimi PhD, M Ghasemi-Kasman PhD), Immunoregulation Research Center (Prof S Seyedmousavi PhD), Infectious Diseases and Tropical Medicine Research Center (A Rostami PhD), Social Determinant of Health Research Center (A Bijani PhD), Student Research Committee (M Zamani MD), Babol University of Medical Sciences, Babol, Iran (M Faramarzi PhD, Prof A Moghadamnia PhD, S Mouodi MD); Woldia University, Woldia, Ethiopia (N Bililign BHLthSci); Department of Clinical Pharmacy and Pharmacology (M Bin Sayeed MSPS), University of Dhaka, Ramna, Bangladesh; Department of Medical and Surgical Sciences (A Farioli PhD, Prof F S Violante MPH), University of Bologna, Bologna, Italy (S M Birlık MBA); Liaison of Turkey (S M Birlık MBA), Guillaumin-Barre Syndrome/Chronic Inflammatory Demyelinating Polyneuropathy Foundation International, Conshohocken, PA, USA; Center for the AID Program of Research in South Africa (CAPRISA) TB and HIV Pathogenesis Unit (K E Oladimeji MPH), Fast-Track Implementation Department (C Birungi MSc), United Nations Programme on HIV/AIDS (UNAIDS), Gaborone, Botswana; Global Health Division (D Bisanzio PhD), Research Triangle Institute International, Research Triangle Park, NC, USA; School of Medicine (D Bisanzio PhD, F Shokraneh MS), University of Nottingham, Nottingham, UK; Department of Health Sciences (I Filip MD), A T Still University, Brisbane, QLD, Australia (T Biswas MPH, A Radfar MD, M Soosaraei PhD); Department of Nursing (M T Haile MSc), Department of Public Health (H Bizuneh MPH), St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia; Department of Health Management and Health Economics (Prof A Kisa PhD), Institute of Health and Society (A S Winkler PhD), University of Oslo, Oslo, Norway (Prof E Bjertness PhD); Institute for Social Science Research (A A Mamun PhD, J C Maravilla PhD), Queensland Alliance for Agriculture and Food innovations (E M Bobasa MSc), Queensland Brain Institute (Prof J J McGrath MD), School of Dentistry (R Lalloo PhD), The University of Queensland, Brisbane, QLD, Australia (J Leung PhD, Prof H A Whiteford PhD); National Drug and Alcohol Research Centre (Prof L Degenhardt PhD), School of Medicine (P K Maulik PhD), School of Psychiatry (Prof P B Mitchell MD, Prof P S Sachdev PhD), School of Public Health and Community Medicine (J Jonnagaddala MD), Transport and Road Safety Research (S Boufous PhD), University of New South Wales, Sydney, NSW, Australia; Vision & Eye Research Unit (Prof R Bourne MD), Anglia Ruskin University, Cambridge, UK; Department of General Practice and Health Services Research (K Bozorgmehr MD), Heidelberg University Hospital, Heidelberg, Germany; University of Genoa, Genoa, Italy (N L Bragazzi PhD); Department for Clinical Neurosciences and Preventive Medicine (Prof M Brainin MD), Danube University Krems, Krems, Austria; Department of Maternal and Child Nursing and Public Health (Prof D C Malta PhD), Hospital of the Federal University of Minas Gerais (B R Nascimento PhD, Prof A P Ribeiro MD), Nutrition Department (Prof R M Claro PhD), Post-Graduate Program in Infectious Diseases and Tropical Medicine (B P Sao Jose PhD), School of Medicine and Clinical Hospital (Prof L C Brant PhD), Federal University of Minas Gerais, Belo Horizonte, Brazil; Department of Pediatrics (Prof N Kisson MD, S Murthy MD), School of Population and Public Health (Prof M Brauer DSc, Z A Butt PhD, Prof N Sarrafzadegan MD), University of British Columbia, Vancouver, BC, Canada (J A Kopec PhD); Institute of Epidemiology (A Brazinova MD), Comenius University, Bratislava, Slovakia; College of Public Health (M Yotebieng PhD), Department of Psychology (Prof N J K Breitborde PhD), Psychiatry and Behavioral Health Department (Prof N J K Breitborde PhD), The Ohio State University, Columbus, OH, USA; Neuroscience (G Britton PhD), Tuberculosis Biomarker Research Unit (A Goodridge PhD), Institute for Scientific Research and High Technology Services, City of Knowledge, Panama; Department of Research and Health Technology Assessment (F Castro MD), Gorgas Memorial Institute for Health Studies, Panama, Panama (G Britton PhD); Partners In Health, Boston, MA, USA (G Bukhman MD); Al Shifa School of Public Health (Z A Butt PhD), Al Shifa Trust Eye Hospital, Rawalpindi, Pakistan; School of Medicine (J Campuzano Rincon PhD), University of the Valley of Cuernavaca, Cuernavaca, Mexico; Centre for Population Health Sciences (J Car PhD), LKCMedicine (M Soljak PhD), Lee Kong Chian School of Medicine

(L Tudor Car PhD), Nanyang Technological University, Singapore, Singapore (S Thirunavukkarasu PhD); Department of Primary Care and Public Health (M Car PhD, Prof A Majeed MD, Prof S Rawaf PhD, M Soljak PhD), Department of Surgery and Cancer (Prof A C Davis PhD), Global eHealth Unit (J Car PhD), School of Public Health (Prof S Saxena MD), WHO Collaborating Centre for Public Health Education and Training (D L Rawaf MD, H Shoman MPH), Imperial College London, London, UK; Ministry of Health, Zagreb, Croatia (M Car PhD); Department of Population and Health (Prof R Cárdenas DSc), Metropolitan Autonomous University, Mexico City, Mexico; Applied Molecular Biosciences Unit (Prof F Carvalho PhD), Institute for Research and Innovation in Health (i3S) (J das Neves PhD), Institute of Biomedical Engineering (INEB) (J das Neves PhD), Institute of Public Health (Prof F Carvalho PhD), REQUIMTE/LAQV (Prof E Fernandes PhD, Prof D M Pereira PhD), UCIBIO (J P Silva PhD), University of Porto, Porto, Portugal; Colombian National Health Observatory (C A Castañeda-Orjuela MD), National Center for the Prevention and Control of HIV and AIDS (C Magis-Rodriguez PhD), National Centre for Disease Prevention and Health Promotion (A Spinelli MSc), National Institute of Health, Bogota, Colombia; Epidemiology and Public Health Evaluation Group (C A Castañeda-Orjuela MD), National University of Colombia, Bogota, Colombia; Department of Public Health (B Kucuk Bicer BEP), Institute of Population Studies (A Çavlin PhD), Hacettepe University, Ankara, Turkey; Mary MacKillop Institute for Health Research (Prof E Cerin PhD), The Brain Institute (Prof C E I Szoeko PhD), Australian Catholic University, Melbourne, VIC, Australia; Centre for Suicide Research and Prevention (Prof P Yip PhD), School of Public Health (Prof E Cerin PhD), University of Hong Kong, Hong Kong, China (Prof P Yip PhD); College of Medicine (Y Chaiah, Prof Z A Memish MD, M Temsah MD, O Temsah), Alfaisal University, Riyadh, Saudi Arabia; Health Systems Research Center (Prof J C Montañez MSc), Institute of Population Health Sciences (Prof H Chang DrPH), National Health Research Institutes, Zhunan Township, Taiwan; College of Medicine (J Chang PhD), National Taiwan University, Taipei, Taiwan; Department of Development Studies (A Chattopadhyay PhD), Department of Fertility Studies (B K Panda MA), Department of Population Studies (A Patle MPH), Department of Public Health & Mortality Studies (M H Rahman MPH, Prof U Ram PhD), International Institute for Population Sciences, Mumbai, India (S Goli PhD, P Kumar PhD); Faculty of Medical Sciences (V Chattu MD), University of the West Indies, St Augustine, Trinidad and Tobago; Independent Consultant, Athens, Greece (V Chattu MD); Surgical Oncology (Prof P Chaturvedi MD), Tata Memorial Hospital, Mumbai, India; Clinical Governance (P P Chiang PhD), Gold Coast Health, Gold Coast, QLD, Australia; Centre of Cardiovascular Research and Education in Therapeutics (R Ofori-Asenso MSc), Department of Epidemiology and Preventive Medicine (K L Chin PhD), Monash Centre for Health Research and Implementation (B de Courten PhD), School of Public Health and Preventive Medicine (Prof F M Cicuttini PhD, Prof Y Guo PhD, S Li PhD, S Si PhD), Monash University, Melbourne, VIC, Australia (Prof A G Thrift PhD); Department of Population Studies (V H Chisumpa PhD, C Mapoma PhD), University of Zambia, Lusaka, Zambia; Demography and Population Studies (V H Chisumpa PhD), University of the Witwatersrand, Johannesburg, South Africa; Ministry of Health, Bagdad, Iraq (A Chitheer MD); Biochemistry, Biomedical Science (J J Choi PhD), Seoul National University Hospital, Seoul, South Korea; Department of Public Health and Primary Care (R Chowdhury PhD), University of Cambridge, Cambridge, UK; Department of Neurology (T C Truelsen PhD), Institute of Clinical Medicine and Bispebjerg Hospital (Prof H Christensen DMSc), University of Copenhagen, Copenhagen, Denmark; Department of Community Health (A M Oommen MD), Department of Endocrinology (Prof N Thomas PhD), Department of Neurology (Prof J D Pandian MD), Department of Pulmonary Medicine (Prof D J Christopher MD), Christian Medical College and Hospital, Vellore, India; Health Data Research UK, London, UK (S Chung PhD); Adelaide Medical School (L G Ciobanu PhD, T K Gill PhD), Joanna Briggs Institute (J Opio MPH), Robinson Research Institute (Z S Lassi PhD), University of Adelaide, Adelaide, SA, Australia (A T Olagunju MD); Scuola Medica Salernitana (M Cirillo MD), University of Salerno, Baronissi, Italy;

Department of Health Assessments & Forecasting (T K D Claßen DrRerNat), North Rhine-Westphalia Centre for Health, Bochum, Germany; Bielefeld School of Public Health (T K D Claßen DrRerNat), Department of Public Health Medicine (F Fischer PhD), Bielefeld University, Bielefeld, Germany; Health Effects Institute, Boston, MA, USA (A J Cohen DSc); Faculty of Business and Management (M A Garcia-Gordillo PhD), Faculty of Education (D Collado-Mateo MSc), Institute of Physical Activity and Health (Prof P R Olivares PhD), Autonomous University of Chile, Talca, Chile; NIHR Oxford Biomedical Research Centre (Prof C Cooper MEd), University of Southampton, Southampton, UK (Prof C Cooper MEd); Department of Cardiovascular Medicine (L T Cooper MD), Mayo Clinic, Jacksonville, FL, USA; T Denny Sanford School of Social and Family Dynamics (M Costa PhD), Arizona State University, Tempe, AZ, USA; Division of Reproductive Health (M Costa PhD), Centers for Disease Control and Prevention, Atlanta, GA, USA; Department of Internal Medicine - Neurology (Prof S C O Martins PhD), Postgraduate Program in Epidemiology (E Cousin MS, B B Duncan MD, Prof B N G Goulart DSc, Prof M I Schmidt PhD), Federal University of Rio Grande do Sul, Porto Alegre, Brazil; College of Medicine and Health Sciences (A K Daba MSc), Department of Reproductive Health (D T Hibstu MPH), School of Nursing and Midwifery (Z Y Kassa MSc), Hawassa University, Hawassa, Ethiopia; Discipline of Public Health (A F Dadi MPH), Flinders University, Adelaide, SA, Australia; Institute for Global Health Innovations (A K Dang MD, H P Do PhD, G H Ha MBA, H L T Nguyen MPH, T T Tran BMedSc), Duy Tan University, Hanoi, Vietnam; Biomedical Research Council (Prof C D A Wolfe MD), Clinical Toxicology Service (Prof P I Dargan MB), Guy's and St Thomas' NHS Foundation Trust, London, UK; Department of Rheumatology (Prof S K Das MD), K G Medical University, Lucknow, India; James P Grant School of Public Health (R Das Gupta MPH, M Hasan MPH, I Sutradhar MPH), Research and Evaluation Division (M Rahman PhD), BRAC University, Dhaka, Bangladesh; Central University of Tamil Nadu (Prof A P Dash DSc), Central University Tamil Nadu, Thiruvavur, India; Department of Surgery (D V Davitoiu PhD), Clinical Emergency Hospital Sf Pantelimon, Bucharest, Romania; Kazakh National Medical University, Almaty, Kazakhstan (K Davletov PhD); Department of Surgery (A Dayama MD), San Joaquin General Hospital, French Camp, CA, USA; Department of Diabetes and Vascular Medicine (B de Courten PhD), Monash Health, Melbourne, VIC, Australia; Australian Institute for Suicide Research and Prevention (Prof D De Leo DSc), Menzies Health Institute Queensland (S K Tadakamadla PhD), Griffith University, Mount Gravatt, QLD, Australia; Department of Agricultural Economics (H De Steur PhD), Department of Food Technology, Safety and Health (C Lachat PhD), Ghent University, Ghent, Belgium; Maternal and Child Wellbeing Unit (T A Zerfu PhD), Population Dynamics and Reproductive Health Unit (T T Degfie PhD), African Population Health Research Centre, Nairobi, Kenya; School of Medicine (Prof R P Dellavalle MD), University of Colorado Denver, Aurora, CO, USA; Dermatology Service (Prof R P Dellavalle MD), US Department of Veterans Affairs, Denver, CO, USA; Department of Clinical Pharmacy (G T Demoz MSc), Department of Medical Laboratory Sciences (M Teweldemedhin MSc), Aksum University, Aksum, Ethiopia; Department of Global Health and Infection (K Deribe PhD), Brighton and Sussex Medical School, Brighton, UK; National Health Service Scotland, Edinburgh, UK (N Dervenis MD); Aristotle University of Thessaloniki, Thessaloniki, Greece (N Dervenis MD); Disha Foundation, Gurgaon, India (S Dey PhD); Department of Community Medicine (S D Dharmaratne MD), University of Peradeniya, Peradeniya, Sri Lanka; Health Research Section (M Dhimal PhD), Nepal Health Research Council, Kathmandu, Nepal; Center of Communicable Disease Control (B Eshtrati PhD), Deputy of Research and Technology (S Djalalinia PhD), Ministry of Health and Medical Education, Tehran, Iran (Z Kazemi MSc, A Khosravi PhD); Department of Social Medicine and Health Care Organisation (K Dokova PhD), Medical University of Varna, Varna, Bulgaria; Conservation Biology and Entomology (A A Kudom PhD), Department of Population and Health (D T Doku PhD), University of Cape Coast, Cape Coast, Ghana; Faculty of Social Sciences (P KC DipSocSc, S Neupane PhD), Faculty of Social

Sciences, Health Sciences (D T Doku PhD), University of Tampere, Tampere, Finland; Asbestos Diseases Research Institute (J Leigh MD), Sydney Medical School (S Islam PhD), Sydney School of Public Health (Prof T R Driscoll PhD), University of Sydney, Sydney, NSW, Australia (D G Hoy PhD, M A Mohammed PhD); Division of Injury Prevention and Mental Health Improvement (P Ye MPH), National Center for Chronic and Noncommunicable Disease Control and Prevention (L Duan MD, M Zhou PhD), Chinese Center for Disease Control and Prevention, Beijing, China (Prof X Liang MD); United Nations World Food Programme, New Delhi, India (M Dubey PhD); Institute of Public Health (Prof D Rasella PhD), School of Medicine (Prof A R Duraes PhD), Federal University of Bahia, Salvador, Brazil; Roberto Santos General Hospital, Salvador, Brazil (Prof A R Duraes PhD); Department of Nursing (Prof D Edvardsson PhD), Umeå University, Umeå, Sweden; Eijkman-Oxford Clinical Research Unit (I R Elyazar PhD), Eijkman Institute for Molecular Biology, Jakarta, Indonesia; Public Health Department (A Y Endries MPH), Saint Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia; Department of Medical Parasitology and Mycology (H Fakhim PhD), Urmia University of Medical Science, Urmia, Iran; Nutrition and Food Systems Division (Prof J Fanzo PhD), Food and Agriculture Organization of the United Nations, Rome, Italy; College of Medicine (M Fareed PhD), Department of Public Health (A T Khoja MD), Imam Muhammad Ibn Saud Islamic University, Riyadh, Saudi Arabia; Division of Cardiovascular Medicine (T A Farid MD, G Vaidya MD), University of Louisville, Louisville, KY, USA; National Statistical Office, Lisbon, Portugal (C S e Farinha MSc); Department of Psychology (Prof A Faro PhD), Federal University of Sergipe, Sao Cristovao, Brazil; Chronic Diseases (Home Care) Research Center (M Shamsizadeh MSc), Department of Epidemiology (M Karami PhD), Social Determinant of Health Research Center (A Fazaeli PhD), Hamadan University of Medical Sciences, Hamadan, Iran; National Institute for Stroke and Applied Neurosciences (Prof V L Feigin PhD), Auckland University of Technology, Auckland, New Zealand; Health Division (A B Feigl PhD), Organisation for Economic Co-operation and Development, Paris, France; Center for Biotechnology and Fine Chemistry (J C Fernandes PhD), Catholic University of Portugal, Porto, Portugal; Heller School for Social Policy & Management (D O Fijabi MD), Brandeis University, Waltham, MA, USA; School of Public Health (D O Fijabi MD), University of Memphis, Memphis, TN, USA; Department of Psychiatry (I Filip MD), Kaiser Permanente, Fontana, CA, USA; Department of Epidemiology and Health Monitoring (J D Finger PhD, G B M Mensink PhD), Robert Koch Institute, Berlin, Germany; Sergio Arouca National School of Public Health, Rio de Janeiro, Brazil (L S Flor MPH); Federal University of Espirito Santo, Vitoria, Brazil (L S Flor MPH); Institute of Gerontology (N A Foigt PhD), National Academy of Medical Sciences of Ukraine, Kyiv, Ukraine; College of Public Health, Medical and Veterinary Science (R C Franklin PhD), James Cook University, Townsville, QLD, Australia; Gene Expression & Regulation Program (T Fukumoto PhD), Cancer Institute, Philadelphia, PA, USA; Department of Dermatology (T Fukumoto PhD), Kobe University, Kobe, Japan; Epidemiology and Public Health (T Fürst PhD), Swiss Tropical and Public Health Institute, Basel, Switzerland; University of Basel, Basel, Switzerland (T Fürst PhD); Faculty of Medicine and Pharmacy of Fez (F G Gankpe MD), University Sidi Mohammed Ben Abdellah, Fez, Morocco; Department of Nephrology (Prof R T Gansevoort PhD), Department of Psychiatry (Prof H W Hoek MD), University Medical Center Groningen, Groningen, Netherlands; Institute of Hygiene and Tropical Medicine (A C Garcia MPH), Nova University of Lisbon, Lisbon, Portugal; Epidemiology Department (A C Garcia MPH), National Health Institute Doutor Ricardo Jorge (INSA), Lisbon, Portugal; International Trachoma Initiative (T Gebre PhD), Task Force for Global Health, Decatur, GA, USA; School of Public Health (A T Gebremedhin MPH, D Hendrie PhD, T R Miller PhD), Curtin University, Perth, WA, Australia; Division of Human Nutrition and Health (Prof J M Geleijnse PhD), Wageningen University & Research, Wageningen, Netherlands; Institute of Epidemiology, Biostatistics and Informatics (S Getachew MPH), Institute of Medical Epidemiology (I Shiu Phd), Martin Luther University Halle-Wittenberg, Halle, Germany; Social Determinants of Health Research Center (H Ghiasvand PhD), University of Social Welfare and Rehabilitation Sciences, Iran (Z Jorjoran Shushtari PhD, M Noroozi PhD); Department of Health Care Policy and Management (M Ghimire MA), University of Tsukuba, Tsukuba, Japan; Department of Respiratory Medicine (Prof A G Ghoshal MD), National Allergy, Asthma, and Bronchitis Institute, Kolkata, India; Department of Respiratory Medicine (Prof A G Ghoshal MD), Fortis Hospital, Kolkata, India; Department of Cardiovascular, Dysmetabolic, and Ageing-Associated Diseases (S Giampaoli MD), National Public Health Institute, Rome, Italy; Department of Public Health (S Giampaoli MD), Texas Tech University, Lubbock, TX, USA; Division of Health Sciences (O A Uthman PhD), Unit of Academic Primary Care (Prof P S Gill DM), University of Warwick, Coventry, United Kingdom; Research Center of Neurology, Moscow, Russia (E V Gnedovskaya PhD, M A Kravchenko PhD); Center for the Study of Regional Development (S Goli PhD), Centre for Ethics (T Khanna PhD), Jawahar Lal Nehru University, New Delhi, India; Nursing and Health Sciences Department (P N Gona PhD), University of Massachusetts Boston, Boston, MA, USA; Department of Biostatistics and Epidemiology (S V Gopalani MPH), University of Oklahoma, Oklahoma City, OK, USA; Department of Health and Social Affairs (S V Gopalani MPH), Government of the Federated States of Micronesia, Palikir, Federated States of Micronesia; Metabolic Epidemiology Section (A Goto MD), National Cancer Center, Chuo-ku, Japan; School of Medicine (A Grada MD), Boston University, Boston, MA, USA; Registro Tumori Integrato (G Grosso PhD), Vittorio Emanuele University Hospital Polyclinic, Catania, Italy; Department of Epidemiology (Prof H C C Gugnani PhD), Department of Microbiology (Prof H C C Gugnani PhD), Saint James School of Medicine, The Valley, Anguilla; School of Public Health (Prof F Guillemin PhD), University of Lorraine, Vandoeuvre-les-Nancy, France; School of Dentistry (Prof A L S Guimaraes PhD), State University of Montes Claros, Montes Claros, Brazil; Department of Epidemiology (P C Gupta DSc, D N Sinha PhD), Healis Sekhsaria Institute for Public Health, Mumbai, India; Commissioner of Public Health (Prof R Gupta MD), West Virginia Bureau for Public Health, Charleston, WV, USA; Department of Health Policy, Management & Leadership (Prof R Gupta MD), West Virginia University School of Public Health, Morgantown, WV, USA; Academics and Research (Prof R Gupta MD), Rajasthan University of Health Sciences, Jaipur, India; Department of Preventive Cardiology (Prof R Gupta MD), Eternal Heart Care Centre & Research Institute, Jaipur, India; Department of Cardiology (T Gupta MD), Montefiore Medical Center, Bronx, NY, USA; Department of Epidemiology and Population Health (H Hosgood PhD), Albert Einstein College of Medicine, Bronx, NY, USA (T Gupta MD); Department of Public Health (J A Haagsma PhD, S Kochhar MD), Erasmus University Medical Center, Rotterdam, Netherlands; Lawson Health Research Institute, London, ON, Canada (V Hachinski DSc); Department of Family and Community Medicine (Prof R R Hamadeh DPhil), Arabian Gulf University, Manama, Bahrain; School of Health and Environmental Studies (Prof S Hamidi DrPH), Hamdan Bin Mohammed Smart University, Dubai, United Arab Emirates; Neurology Department (Prof G J Hankey MD), Sir Charles Gairdner Hospital, Perth, WA, Australia; Department of Disease, Epidemics, and Pandemics Control (J Nansseu MD), Department of Vital and Health Statistics (H L Harb MPH), Ministry of Public Health, Beirut, Lebanon; Achutha Menon Centre for Health Science Studies (P Jeemon PhD, G Mini PhD, Prof K R Thankappan MD), Cardiology Department (Prof S Harikrishnan MD), Neurology Department (Prof P Sylaja MD), Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, India (Prof P Sylaja MD); Health Education and Health Promotion Department, School of Public Health (L Jahangir PhD), Tabriz University of Medical Sciences, Tabriz, Iran (H Haririan PhD, H Hassankhani PhD); Research and Development Unit (Prof J M Haro MD, A Koyanagi MD), San Juan de Dios Sanitary Park, Sant Boi de Llobregat, Spain; Department of Medicine (Prof J M Haro MD), University of Barcelona, Barcelona, Spain; Independent Consultant, Tabriz, Iran (H Hassankhani PhD); Unit of Epidemiology and Social Medicine (H Y Hassen MPH), University Hospital Antwerp, Wilrijk, Belgium; Clinical Sciences (R Havmoeller PhD), Karolinska University Hospital, Stockholm, Sweden; Endocrinology and Metabolism Research Center (B Heidari MD), Teikyo University School of Medicine, Tehran, Iran;

Department of Environmental Health Engineering (M Heidari PhD), Hormozgan University of Medical Sciences, Bandar Abbas, Iran; Department of Statistics and Econometrics (Prof C Herteliu PhD, A Pana MD), Bucharest University of Economic Studies, Bucharest, Romania; A C S Medical College and Hospital, Nastaran, Iran (B Heydarpour BEP, Prof U Kapil MD); Research Coordination (Prof M Hijar PhD), AC Environments Foundation, Cuernavaca, Mexico; Department of Epidemiology (Prof H W Hoek MD), Department of Health and Behavior Studies (Prof I D Sigfusdottir PhD), Columbia University, New York, NY, USA; Department of Nutritional Sciences (D J Hoffman PhD), Rutgers University, New Brunswick, NJ, USA; University of Texas Austin, Austin, TX, USA (M K Hole MD); Guilan Road Trauma Research Center (E Homaie Rad PhD), School of Health (E Homaie Rad PhD), Guilan University of Medical Sciences, Rasht, Iran; Transdisciplinary Centre for Qualitative Methods (P Hoogar PhD), Manipal University, Manipal, India; Department of Pulmonology (N Horita PhD), Yokohama City University, Kanazawa-ku, Yokohama, Japan; Center for Translation Research and Implementation Science (G A Mensah MD), Institute of Health Policy and Development Studies (Prof H Lam PhD), National Heart, Lung, and Blood Institute (E K Peprah PhD), National Human Genome Research Institute (N Horita PhD), National Institutes of Health, Bethesda, MD, USA (A Pervaiz MHA); Department of Computer Science (M Hosseinzadeh PhD), University of Human Development, Sulaimaniyah, Iraq (M Hosseinzadeh PhD); Department of Internal Medicine (M Hostiuc PhD), Bucharest Emergency Hospital, Bucharest, Romania; Clinical Legal Medicine (S Hostiuc PhD), National Institute of Legal Medicine Mina Minovici, Bucharest, Romania; Faculty of Medicine Tunis (Prof M Hsairi MPH), Medicine School of Tunis, Baab Saadoun, Tunisia; Department of Epidemiology and Health Statistics (Prof G Hu PhD), Central South University, Changsha, China; Solar Cookers International, Sacramento, CA, USA (C Hughes MA); School of Public Health (Prof E U Igumbor PhD), University of the Western Cape, Bellville, Cape Town, South Africa; Department of Public Health (Prof E U Igumbor PhD), Walter Sisulu University, Mthatha, South Africa; Department of Public Health and Community Medicine (O S Ilesanmi PhD), University of Liberia (O S Ilesanmi PhD), University of Liberia, Monrovia, Liberia; Global Health and Development Department (Prof U Iqbal PhD), Graduate Institute of Biomedical Informatics (D N A Ningrum MPH), Taipei Medical University, Taipei, Taiwan; Department of Psychology (M A Stokes PhD), Institute for Physical Activity and Nutrition (S Islam PhD), School of Medicine (P Lamichhane PhD, M Rahman PhD), Deakin University, Burwood, VIC, Australia; Surveillance and Health Services Research (F Islami PhD), American Cancer Society, Atlanta, GA, USA; Department of Global and Community Health (K H Jacobsen PhD), George Mason University, Fairfax, VA, USA; Department of Parasitic Diseases (S K Jain MD), National Centre for Disease Control Delhi, Delhi, India; Medical Sciences Department (Prof M Jakovljevic PhD), University of Kragujevac, Kragujevac, Serbia; Department of Internal Medicine (S K Jassal MD), University of California San Diego, San Diego, CA, USA; Newcastle University, Tyne, UK (M Javanbakht PhD); Faculty of Graduate Studies (A U Jayatileke PhD), Institute of Medicine (A U Jayatileke PhD), University of Colombo, Colombo, Sri Lanka; Department of Community Medicine (R P Jha MSc), Department of Medicine (O Singh PhD), Banaras Hindu University, Varanasi, India; Environmental Research Center (J S Ji DSc), Global Health Research Center (L L Yan PhD), Duke Kunshan University, Kunshan, China; Beijing Institute of Ophthalmology (Prof J B Jonas MD), Beijing Tongren Hospital, Beijing, China; New South Wales Health, Sydney, NSW, Australia (J Jonnagaddala PhD); Centre for Community Medicine (A Joshi MD, A P Pakhare MD), Department of Cardiology (Prof N Naik DM, Prof A Roy MD), Department of Endocrinology, Metabolism, & Diabetes (Prof N Tandon PhD), Department of Paediatrics (Prof R Lodha MD), Department of Psychiatry (Prof R Sagar MD), All India Institute of Medical Sciences, New Delhi, India; Institution of Health and Nutrition Sciences (J J Jozwiak PhD), Czestochowa University of Technology, Czestochowa, Poland; Faculty of Medicine and Health Sciences (J J Jozwiak PhD), University of Opole, Opole, Poland; School of Health Sciences (S B Jungari MA), Savitribai Phule Pune University, Pune, India; Institute of Family Medicine and Public Health (M Jürisson PhD), University of Tartu, Tartu, Estonia; Department of Community Medicine (M K MD), Employees' State Insurance Model Hospital, Chennai, India; School of Public Health (Z Kabir PhD), University College Cork, Cork, UK; Department of Public Health (M Kahssay MPH, M L Liben MPH), Samara University, Samara, Ethiopia; European Observatory on Health Systems and Policies, London, UK (M Karanikolos MPH); School of Interdisciplinary Arts and Sciences (S Karimi PhD), University of Washington Tacoma, Tacoma, WA, USA; Baqiyatallah Research Center for Gastroenterology and Liver Diseases (H Karimi-Sari MD), Student Research Committee (M Khosravi MD), Baqiyatallah University of Medical Sciences, Tehran, Iran; Department of Molecular Hepatology (H Sharafi PhD), Department of Young Investigators (H Karimi-Sari MD), Middle East Liver Disease Center, Tehran, Iran; Department of Anesthesiology & Pain Medicine (N J Kassebaum MD), Seattle Children's Hospital, Seattle, WA, USA; MRC/CSO Social and Public Health Sciences Unit (S V Katikireddi PhD), University of Glasgow, Glasgow, UK; School of Health Care Administration (Prof A Kaul MD), Oklahoma State University, Tulsa, OK, USA; Health Care Delivery Sciences (Prof A Kaul MD), University of Tulsa, Tulsa, OK, USA; Department of Epidemiology and Biostatistics (D S Kazi MD, K M Mehta DSc), Department of Medicine (D S Kazi MD), University of California San Francisco, San Francisco, CA, USA; Midwifery Program (S Kebede MSc), Salale University, Fiche, Ethiopia; ODeL campus (Prof P N Keiyoro PhD), School of Medicine (Prof G Yonga MD), University of Nairobi, Nairobi, Kenya (M Kumar PhD); Department of Linguistics and Germanic, Slavic, Asian, and African Languages (G R Kemp BA), Michigan State University, East Lansing, MI, USA; Alcohol, Tobacco, & Other Drug Use Research Unit (Prof C D H Parry PhD), Cochrane South Africa (E Z Sambala PhD, A B Wiyeh MD, Prof C S Wiysonge MD), Non-Communicable Diseases Research Unit (Prof A P Kengne PhD), Medical Research Council South Africa, Cape Town, South Africa; Department of Medicine (Prof A P Kengne PhD, G A Mensah MD, J Noubiap MD, M S Shey PhD, Prof K Sliwa MD, L J Zuhlke PhD), Department of Paediatrics and Child Health (L J Zuhlke PhD), Department of Psychiatry and Mental Health (Prof D J Stein MD), Institute of Infectious Disease and Molecular Medicine (M S Shey PhD), University of Cape Town, Cape Town, South Africa; Institute of Cardiology (Prof A Keren MD), Assuta Hospital, Tel Aviv Yaffo, Israel; Heart Failure and Cardiomyopathies Center (Prof A Keren MD), Hadassah Hebrew University Hospital, Jerusalem, Israel; CSIR-Indian Institute of Toxicology Research (C Kesavachandran PhD), Council of Scientific & Industrial Research, Lucknow, India; Department of Public Health and Community Medicine (Prof Y S Khader PhD), Jordan University of Science and Technology, Ramtha, Jordan; Department of Statistics (B Khafaei PhD), Azad University, Omidiyeh Branch, Iran; School of Food and Agricultural Sciences (N Khalid PhD), University of Management and Technology, Lahore, Pakistan; Epidemiology and Biostatistics Department (E A Khan MPH), Health Services Academy, Islamabad, Pakistan; Department of Internal Medicine (M S Khan MD), John H Stroger, Jr Hospital of Cook County, Chicago, IL, USA; Department of Internal Medicine (M S Khan MD, T J Siddiqi MB, M S Usman MB), Dow University of Health Sciences, Karachi, Pakistan; Department of Epidemiology (G Naik MPH, J A Singh MD), Department of Medicine (P Ranjan PhD, J A Singh MD), Department of Psychology (D C Schwebel PhD), University of Alabama at Birmingham, Birmingham, AL, USA (M Khan MD, A R Sawant MD); Department of Pediatrics (Prof J A Towbin MD), University of Tennessee, Knoxville, TN, USA (M Khan MD); Department of Health Policy and Management (Prof Y Khang MD), Institute of Health Policy and Management (Prof Y Khang MD), Seoul National University, Seoul, South Korea; Department of Health Research (T Khanna PhD), National Institute for Research in Environmental Health (Y D Sabde MD), National Institute of Nutrition (Prof A Laxmaiah PhD), Regional Medical Research Centre (S Pati MD), Indian Council of Medical Research, New Delhi, India; International Otorhinolaryngology Research Association, Tehran, Iran (M Khosravi MD); Department of Nutrition and Health Science (Prof J Khubchandani PhD), Ball State University, Muncie, IN, USA; Clinical Epidemiology Unit (A A Kiadaliri PhD), Department of Clinical

Sciences (Prof B Norrving PhD), Lund University, Lund, Sweden; Ministry of Health, Nairobi, Kenya (H W Kiarie MSc); Kenya Revenue Authority, Nairobi, Kenya (D N Kiirithio MSc); Research and Data Solutions (D N Kiirithio MSc), Synotech Consultant, Nairobi, Kenya; Department of Health Sciences (Prof D Kim DrPH), Northeastern University, Boston, MA, USA; Department of Preventive Medicine (Y Kim PhD, Prof S Yoon PhD), Korea University, Seoul, South Korea; School of Medicine (Y Kim PhD), Xiamen University Malaysia, Sepang, Malaysia; Department of Nutrition (R W Kimokoti MD), Simmons College, Boston, MA, USA; Faculty of Health (Y Kinfu PhD), University of Canberra, Canberra, ACT, Australia; Department of Global Community Health and Behavioral Sciences (Prof A Kisa PhD), Tulane University, New Orleans, LA, USA; Department of Health Economics and Social Security (K Kissimova-Skarbek PhD), Institute of Public Health (R Topor-Madry PhD), Jagiellonian University Medical College, Krakow, Poland; Department of Public Health (Prof M Kivimäki PhD), University of Helsinki, Helsinki, Finland (T J Meretoja MD); Public Health Sciences Division (J M Kocarnik PhD), Fred Hutchinson Cancer Research Center, Seattle, WA, USA; Department of Preventive Cardiology (Prof Y Kokubo PhD), National Cerebral and Cardiovascular Center, Suita, Japan; Arthritis Research Canada, Richmond, BC, Canada (J A Kopeck PhD); Independent Consultant, Jakarta, Indonesia (S Kosen MD); Department of Internal and Pulmonary Medicine (Prof P A Koul MD), Sheri Kashmir Institute of Medical Sciences, Srinagar, India; Department of Anthropology (K Krishan PhD), Panjab University, Chandigarh, India; Department of Demography (Prof B Kuate Defo PhD), Department of Social and Preventive Medicine (Prof B Kuate Defo PhD), University of Montreal, Montreal, QC, Canada; Department of Public Health (B Kucuk Bicer BEP), Yuksek Ihtisas University, Ankara, Turkey; School of Medicine and Surgery (A Lafranconi MD, F Madotto PhD), University of Milan Bicocca, Monza, Italy; Department of Health Systems and Research Ethics (A K Lagat BS), Kenya Medical Research Institute/Wellcome Trust Research Programme, Nairobi, Kenya (Prof C R J Newton MD); Department of Basic Sciences (A K Lagat BS), Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya; Department of Community and Family Medicine (F H Lami PhD), Academy of Medical Science, Baghdad, Iraq; Division of Cancer Epidemiology & Genetics (Q Lan PhD), National Cancer Institute, Rockville, MD, USA; HelpMeSee, New York, NY, USA (Prof V C Lansingh PhD); International Relations (Prof V C Lansingh PhD), Mexican Institute of Ophthalmology, Queretaro, Mexico; Belo Horizonte City Hall (Prof S Lansky PhD), Municipal Health Department of Belo Horizonte, Belo Horizonte, Brazil; Department of Medical Sciences (Prof A O Larsson PhD), Uppsala University, Uppsala, Sweden; Department of Clinical Chemistry and Pharmacology (Prof A O Larsson PhD), Uppsala University Hospital, Uppsala, Sweden; Disease Control Department (D O Laryea MD), Ghana Health Service, Accra, Ghana; Department of Public Health (A Latifi PhD), Managerial Epidemiology Research Center (S Safiri PhD), Maragheh University of Medical Sciences, Maragheh, Iran; College of Optometry (J L Leasher OD), Nova Southeastern University, Fort Lauderdale, FL, USA; Department of Information and Internet Technologies (Prof G Lebedev PhD, S K Vladimirov PhD), I M Sechenov First Moscow State Medical University, Moscow, Russia; Central Research Institute of Cytology and Genetics (E Varavikova PhD), Department of Mathematical Modeling in Health Care (S Soshnikov BEP), Federal Research Institute for Health Organization and Informatics of the Ministry of Health, Moscow, Russia (Prof G Lebedev PhD, Prof V I Starodubov DSc, S K Vladimirov PhD); School of Nursing (P H Lee PhD), Hong Kong Polytechnic University, Hong Kong, China; School of Social Sciences (M Leinsalu PhD), Södertörn University, Huddinge, Sweden; Department of Epidemiology and Biostatistics (M Leinsalu PhD), National Institute for Health Development, Tallinn, Estonia; Oxford University Clinical Research Unit (S Lewycka PhD), Wellcome Trust Asia Programme, Hanoi, Vietnam; West China Second University Hospital of Sichuan University, Chengdu, China (X Li PhD); Department of Clinical Research and Epidemiology (Y Li PhD, Y Li PhD), Shenzhen Sun Yat-sen Cardiovascular Hospital, Shenzhen, China; National Office for Maternal and Child Health Surveillance, Chengdu, China (Prof J Liang MD, Prof Y Wang MD, Prof J Zhu MD); National Center of Birth Defects Monitoring of China, Chengdu, China (Prof J Liang MD, Prof Y Wang MD); Department of Medicine (L Lim MD), University of Malaya, Kuala Lumpur, Malaysia; Department of Medicine and Therapeutics (L Lim MD), The Chinese University of Hong Kong, Shatin, China; School of Public Health (Prof S Linn DrPH), University of Haifa, Haifa, Israel; Centre for Chronic Disease Control, Beijing, China (Prof S Liu PhD); University of Bari Aldo Moro, Bari, Italy (Prof G Logroscino PhD); Department Clinical Research in Neurology (Prof G Logroscino PhD), Fondazione Cardinale Giovanni Panico Hospital, Tricase, Italy; Department of Medicine (Prof T Wijeratne MD), Department of Paediatrics (M T Mackay PhD, Prof G C Patton MD), School of Health Sciences (A Meretoja MD, Prof C E I Szoeké PhD), School of Population and Global Health (L A Thomas MPH), University of Melbourne, Melbourne, VIC, Australia (Prof A D Lopez PhD); Institute of Nutrition (Prof S Lorkowski PhD), Friedrich Schiller University Jena, Jena, Germany; Competence Cluster for Nutrition and Cardiovascular Health (nutriCARD), Jena, Germany (Prof S Lorkowski PhD); Health Data Research UK (Prof R A Lyons MD), Swansea University, Swansea, UK; Cardiology Department (R G Weintraub MB), Neurology Department (M T Mackay PhD), Royal Children's Hospital, Melbourne, VIC, Australia; Department of Internal Medicine (D P Maghavani MBBS), Grant Medical College & Sir J J Group of Hospitals, Mumbai, India; Institute of Medicine (N B Mahotra MD), Tribhuvan University, Kathmandu, Nepal; Department of Public Health (M Majdan PhD), Trnava University, Trnava, Slovakia; Non-Communicable Diseases Research Center (Prof R Malekzadeh MD, S G Sepanlou MD), Shiraz University of Medical Sciences, Shiraz, Iran; Surgery Department (A Manda MD), Emergency University Hospital Bucharest, Bucharest, Romania; Public Risk Management Institute, Mississauga, ON, Canada (S Mangalam MS); Trade and Competitiveness (S Mangalam MS), World Bank, New York, NY, USA; Department of Physics and Atmospheric Science (Prof R V Martin PhD, A van Donkelaar PhD), Dalhousie University, Halifax, NS, Canada; Neurology Service (Prof S C O Martins PhD), Hospital Moínhos de Vento, Porto Alegre, Brazil; Campus Caucaia (F R Martins-Melo PhD), Federal Institute of Education, Science and Technology of Ceará, Caucaia, Brazil; Department of Biology and Biological Engineering (M Mazidi PhD), Chalmers University of Technology, Gothenburg, Sweden; Department of Ophthalmology (C McAlinden PhD, E Skiadaresi MD), Hywel Dda University Health Board, Carmarthen, UK; National Centre for Register-Based Research (Prof J J McGrath MD), Aarhus University, Aarhus, Denmark; Liver Disease and Hepatitis Program (B J McMahon MD), Alaska Native Medical Center, Anchorage, AK, USA; Research, Monitoring and Evaluation (S Mehta PhD), Ipas Nepal, Kathmandu, Nepal; Neurology Department (Prof M Mehndiratta MD), Janakpuri Super Specialty Hospital Society, New Delhi, India; Preventive Oncology (Prof R Mehrotra PhD), National Institute of Cancer Prevention and Research, Noida, India; Department of Internal Medicine (V Mehta MD), SevenHills Hospital, Mumbai, India; Research Department Prince Mohammed Bin Abdulaziz Hospital, Riyadh, Saudi Arabia (Prof Z A Memish MD); Department of Adult Health Nursing (N Y Tawye MSc), Department of Pharmacy (G Mengistu MSc), Department of Public Health (T C C Mekonnen MPH), Wollo University, Dessie, Ethiopia; College of Health Sciences (A Melese MSc), Debre Tabor University, Debre Tabor, Ethiopia; Department of Public Health (P T N Memiah DrPH), University of West Florida, Pensacola, FL, USA; Peru Country Office (W Mendoza MD), United Nations Population Fund (UNFPA), Lima, Peru; Breast Surgery Unit (T J Meretoja MD), Neurocenter (A Meretoja MD), Helsinki University Hospital, Helsinki, Finland; Clinical Microbiology and Parasitology Unit (T Mestrovic PhD), Dr Zora Profozic Polyclinic, Zagreb, Croatia; University Centre Varazdin (T Mestrovic PhD), University North, Varazdin, Croatia; Ethiopian Academy of Medical Science, Mekelle, Ethiopia (H B Mezgebe MSc); Department of Hypertension (Prof T Miazgowski MD), Emergency Department (B Miazgowski MD), Zdroje Hospital (J Widecka PhD), Pomeranian Medical University, Szczecin, Poland (B Miazgowski MD, K Widecka PhD); Pacific Institute for Research & Evaluation, Calverton, MD, USA (T R Miller PhD); Institutional Research (S P Minnig MS), Bellingham Technical College, Bellingham, WA, USA; Institutional Research (S P Minnig MS), Whatcom Community College, Bellingham,

WA, USA; Nevada Division of Public and Behavioral Health, Carson City, NV, USA (M Mirarefin MPH); Faculty of General Medicine (Prof E M Mirrakhimov MD), Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan; Department of Atherosclerosis and Coronary Heart Disease (Prof E M Mirrakhimov MD), National Center of Cardiology and Internal Disease, Bishkek, Kyrgyzstan; Institute of Addiction Research (ISFF) (B Moazen MSc), Frankfurt University of Applied Sciences, Frankfurt, Germany; Department of Biology (K A Mohammad PhD), Salahaddin University, Erbil, Iraq; ISHIK University, Erbil, Iraq (K A Mohammad PhD); Cardiovascular Research Institute (N Mohammadifard PhD, Prof N Sarrafzadegan MD), Isfahan University of Medical Sciences, Isfahan, Iran; Department of Public Health (M A Mohammed PhD), Jigjiga University, Jigjiga, Ethiopia (A A Tassew MPH); Department of Community Medicine (M B Sufiyan MD), Health Systems and Policy Research Unit (S Mohammed PhD), Ahmadu Bello University, Zaria, Nigeria; Pulmonology and Internal Medicine (Prof M B V Mohan MD), Narayana Health, Bangalore, India; Department of Diabetology (V Mohan DSc), Madras Diabetes Research Foundation, Chennai, India; Clinical Epidemiology and Public Health Research Unit (L Monasta DSc, L Ronfani PhD), Burlo Garofolo Institute for Maternal and Child Health, Trieste, Italy; Department of Epidemiology and Biostatistics (G Moradi PhD), Social Determinants of Health Research Center (G Moradi PhD), Kurdistan University of Medical Sciences, Sanandaj, Iran; Lancaster University, Lancaster, UK (P Moraga PhD); International Laboratory for Air Quality and Health (Prof L Morawska PhD), School of Exercise and Nutrition Sciences (Q G To PhD), Queensland University of Technology, Brisbane, QLD, Australia; Hospital of Sto António (J Morgado-da-Costa MSc), Hospital Center of Porto, Porto, Portugal; Department of Health Policy (Prof R Tobe-Gai PhD), Department of Social Medicine (N Morisaki MD), National Center for Child Health and Development, Setagaya, Japan; Department of Clinical Biochemistry (A Mosapour PhD), Tarbiat Modares University, Tehran, Iran; 1st Department of Ophthalmology (M M Moschos PhD), University of Athens, Athens, Greece; Biomedical Research Foundation (M M Moschos PhD), Academy of Athens, Athens, Greece; Competence Center Mortality-Follow-Up (R Westerman PhD), Demographic Change and Ageing Research Area (A Werdecker PhD), Federal Institute for Population Research, Wiesbaden, Germany (Prof U O Mueller MD); Center for Population and Health, Wiesbaden, Germany (Prof U O Mueller MD); Department of Endocrinology & Metabolism (Prof S Mukhopadhyay MD), Institute of Post Graduate Medical Education & Research, Kolkata, India; National Institute of Epidemiology, Chennai, India (M Murhekar MD); Department of Obstetrics and Gynecology (J Musa MD), University of Jos, Jos, Nigeria; Center for Global Health (J Musa MD), Department of Preventive Medicine (Y Yano MD), Northwestern University, Chicago, IL, USA; School of Medical Sciences (K Musa PhD), Science University of Malaysia, Kubang Kerian, Malaysia; Pediatrics Department (Prof G Mustafa MD), Nishtar Medical University, Multan, Pakistan; Pediatrics & Pediatric Pulmonology (Prof G Mustafa MD), Institute of Mother & Child Care, Multan, Pakistan; Department of Epidemiology (Prof J B Nachega PhD), University of Pittsburgh, Pittsburgh, PA, USA; Department of Research and Analytics, Initiative for Financing and Human Development, Chennai, India (A J Nagarajan MTEch); Institute of Epidemiology and Medical Biometry (Prof G Nagel PhD), Ulm University, Ulm, Germany; Department of Public Health (Prof K Naidoo PhD), Salus University, Philadelphia, PA, USA; Department of Dermatology (Prof L Naldi MD), San Bortolo Hospital, Vicenza, Italy; Direction (Prof L Naldi MD), GISED Study Center, Bergamo, Italy; Department of Preventive Medicine and Public Health (Prof H Nam PhD), Chungnam National University School of Medicine, Daejeon, South Korea; Daejeon Regional Cancer Center (Prof H Nam PhD), Chungnam National University Hospital, Daejeon, South Korea; Suraj Eye Institute, Nagpur, India (V Nangia MD); Department of Public Health (J Nansseu MD), University of Yaoundé I, Yaoundé, Cameroon; Mercy Saint Vincent Medical Center, Toledo, OH, USA (H Nawaz MD); Cardio-Aid, Bucharest, Romania (R I Negoii PhD); Ministry of Health, Community Development, Gender, Elderly and Children, Dar es Salaam, Tanzania (F N Ngalesoni PhD); Department of Biological Sciences (J W Ngunjiri DrPH), University of Embu, Embu, Kenya; Hanoi School of Public Health, Hanoi, Vietnam (A Q Nguyen PhD, H T Nguyen MSc, H T Nguyen PhD); Public Health Science Department (D N A Ningrum MPH), State University of Semarang, Kota Semarang, Indonesia; National Department of Health (N Nolutshungu MD), South African Embassy, Pretoria, South Africa; Department of Global Public Health and Primary Care (Prof O F Norheim PhD), University of Bergen, Bergen, Norway; Institute of Advanced Research (Prof C M Obermeyer DSc), Aix-Marseille University, Marseille, France; Independent Consultant, Accra, Ghana (R Ofori-Asenso MSc); Department of Medicine (O S Ogah PhD), Abia State University, Uturu, Nigeria; School of Social Sciences and Psychology (Prof A M N Renzaho PhD), Western Sydney University, Penrith, NSW, Australia (F A Ogbo PhD); Department of Preventive Medicine (I Oh PhD), Kyung Hee University, Dongdaemung-gu, South Korea; Research, Measurement, and Results (A Okoro MPH), Society for Family Health, Nigeria, FCT, Nigeria; Department of HIV/AIDS, STIs & TB (O Oladimeji MD), Human Sciences Research Council, Durban, South Africa; School of Public Health (O Oladimeji MD), University of Namibia, Oshakati Campus, Namibia; Centre for Healthy Start Initiative, Ikoji, Nigeria (B O Olusanya PhD, J O Olusanya MBA); NCD Prevention & Control Unit, Ministry of Health, Bandar Seri Begawan, Brunei (S Ong MBBS); Institute of Health Science (S Ong MBBS), University of Brunei Darussalam, Gadong, Brunei; Department of Health (J Opio MPH), Lira District Local Government, Lira, Uganda; Graduate School of Public Health (Prof E Oren PhD), San Diego State University, San Diego, CA, USA; Pneumology Service (Prof J B Soriano MD), School of Medicine (Prof A Ortiz MD), Autonomous University of Madrid, Madrid, Spain; Nephrology and Hypertension (Prof A Ortiz MD), The Institute for Health Research Foundation Jiménez Díaz University Hospital, Madrid, Spain; Center for Vaccine Development (J R Ortiz MD), University of Maryland, Baltimore, MD, USA; School of Health and Welfare (Prof E Ortiz-Panozo MD), Jönköping University, Jönköping, Sweden; Department of Global Health Nursing (Prof E Ota PhD), St. Luke's International University, Chuo-ku, Japan; The Center for Healthcare Quality Assessment and Control (S S Oststavnov PhD), Ministry of Health of the Russian Federation, Moscow, Russia; Moscow Institute of Physics and Technology (S S Oststavnov PhD), Moscow State University, Dolgoprudny, Russia; Department of TB & Respiratory Medicine (Prof M P A DNB), Jagadguru Sri Shivarathreeswara University, Mysore, India; Department of Medicine (S Pakhale MD), University of Ottawa, Ottawa, ON, Canada; Institute of Biomedical Sciences, Academia Sinica, Taipei, Taiwan (Prof W Pan PhD); Health Outcomes (A Pana MD), Center for Health Outcomes & Evaluation, Bucharest, Romania; Department of Obstetrics and Gynecology, Attikon University Hospital, Chaidrai, Greece (Prof N Papantoniou PhD); Department of Medical Humanities and Social Medicine (Prof E Park PhD), Kosin University, Busan, South Korea; Department of Medicine (S Patel MD), Maimonides Medical Center, Brooklyn, NY, USA; International Institute of Health Management Research, New Delhi, India (A Patle MPH); Population Health Group (Prof G C Patton MD), Murdoch Childrens Research Institute, Melbourne, VIC, Australia (R G Weintraub MB); Clinical Research Department (Prof V R Paturi MD), Diabetes Research Society, Hyderabad, India; Clinical Research Department (Prof V R Paturi MD), DiabetOmics, Portland, OR, USA; Health, Nutrition, and HIV/AIDS Program (D Paudel PhD), Save the Children, Kathmandu, Nepal; Center for International Health (D Paudel PhD), Ludwig Maximilians University, Munich, Germany; Cartagena University, Cartagena, Colombia (Prof D M Pereira PhD); Independent Consultant, Glenelg, SA, Australia (Prof K Pesudovs PhD); Anesthesiology Department (A S Terkawi MD), School of Medicine (W A Petri MD), University of Virginia, Charlottesville, VA, USA; Institute of Medicine (Prof M Petzold PhD, L Stockfelt PhD), University of Gothenburg, Gothenburg, Sweden; School of Public Health (Prof M Petzold PhD), University of Witwatersrand, Johannesburg, South Africa; Shanghai Mental Health Center (Prof M R Phillips MD), Shanghai Jiao Tong University, Shanghai, China; Basic Medical Sciences Department (J D Pillay PhD), Durban University of Technology, Durban, South Africa; Discipline of General Practice (Prof C D Pond PhD), University of Newcastle, Callaghan, NSW, Australia; University Medical Center Groningen (Prof M J Postma PhD), University of Groningen,

Groningen, Netherlands; Department of Nephrology (S Prakash PhD, Prof N Prasad MD), Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India; Non-communicable Diseases Research Center (M Qorbani PhD), Alborz University of Medical Sciences, Karaj, Iran; School of Public Health (R Quansah PhD), University of Ghana, Accra, Ghana; Medichem, Barcelona, Spain (A Radfar MD); Department of Epidemiology & Biostatistics (A Rafay MS), Department of Public Health (Prof S M Rana PhD), Contech School of Public Health, Lahore, Pakistan; Research Division (M Rahman MHS), Global Public Health Research Foundation, Dhaka, Bangladesh; Department of Clinical Pediatrics (Prof S Rahman MBBS), Sweidi Hospital, Riyadh, Saudi Arabia; Department of Pediatrics (Prof S Rahman MBBS), Hypertension in Africa Research Team (Prof A E Schutte PhD), North-West University, Peshawar, Pakistan; Society for Health and Demographic Surveillance, Suri, India (R Rai MPH); Department of Economics (R Rai MPH, Prof S Vollmer PhD), University of Göttingen, Göttingen, Germany; Medical University Innsbruck, Innsbruck, Austria (S Rajsic MD); Public Health Department (Prof S M Rana PhD), University of Health Sciences, Lahore, Pakistan; Institute for Poverty Alleviation and International Development (C L Ranabhat PhD, C L Ranabhat PhD), Yonsei University, Wonju, South Korea; Gonçalo Moniz Institute (Prof D Rasella PhD), Institute of Scientific and Technological Communication and Information in Health (R d Saldanha MPH), Oswaldo Cruz Foundation, Salvador, Brazil; University College London Hospitals, London, UK (D L Rawaf MD); Public Health England, London, UK (Prof S Rawaf PhD); Department of Preventive Medicine and Occupational Medicine (C Reis MD), Loma Linda University Medical Center, Loma Linda, CA, USA; Brien Holden Vision Institute, Sydney, NSW, Australia (Prof S Resnikoff MD); Organization for the Prevention of Blindness, Paris, France (Prof S Resnikoff MD); Department of Epidemiology (S Riahi PhD), Birjand University of Medical Sciences, Iran; Department of Clinical Research (L Roeber PhD), Federal University of Uberlândia, Uberlândia, Brazil; Golestan Research Center of Gastroenterology and Hepatology (G Roshandel PhD), Golestan University of Medical Sciences, Gorgan, Iran; Biotechnology (E Rubagotti PhD), IKIAM Amazon Regional University, Ciudad de Tena, Ecuador; Department of Ocean Science and Engineering (E Rubagotti PhD), Southern University of Science and Technology, Shenzhen, China; Department of Community Health (B F Sunguya PhD), School of Public Health (G M Ruhago PhD), Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania (B F Sunguya PhD); Neuropsychiatric Institute (Prof P S Sachdev MD), Prince of Wales Hospital, Randwick, NSW, Australia; Medical Department (B Saddik PhD), University of Sharjah, Sharjah, United Arab Emirates; College of Medicine (N Salam PhD), Al-Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia; School of Health and Policy Management (Prof P Salamati MD), York University, Toronto, ON, Canada; Punjab University College of Pharmacy, Anarkali, Pakistan (Z Saleem PharmD); Clinical Research Division (Prof S S Salvi MD), Chest Research Foundation, Pune, India; Health and Disability Intelligence Group, Ministry of Health, Wellington, New Zealand (I Salz MD); Department of Surgery (Prof J Sanabria MD), Marshall University, Huntington, WV, USA; Department of Nutrition and Preventive Medicine (Prof J Sanabria MD), Case Western Reserve University, Cleveland, OH, USA; Nephrology Group (M Sanchez-Niño PhD), Jimenez Diaz Foundation University Hospital Institute for Health Research, Madrid, Spain; Department of Medicine (M Sardana MD), University of Massachusetts Medical School, Worcester, MA, USA; Surgery Department (B Sathian PhD), Hamad Medical Corporation, Doha, Qatar; Faculty of Health & Social Sciences (B Sathian PhD), Bournemouth University, Bournemouth, United Kingdom; UGC Centre of Advanced Study in Psychology (M Satpathy PhD), Utkal University, Bhubaneswar, India; Udyam-Global Association for Sustainable Development, Bhubaneswar, India (M Satpathy PhD); GSK Biologicals, Wavre, Belgium (M Savic PhD); Department of Public Health Sciences (M Sawhney PhD), University of North Carolina at Charlotte, Charlotte, NC, USA; Market Access (M Saylan MD), Bayer, Istanbul, Turkey; School of Health Sciences (Prof I J C Schneider PhD, Prof D A S Silva PhD), Federal University of Santa Catarina, Araranguá, Brazil; Division of Clinical Epidemiology and Aging Research (B Schöttker PhD), German Cancer Research Center, Heidelberg, Germany; Department of Medical Statistics, Epidemiology and Medical Informatics (M Sekerija PhD), University of Zagreb, Zagreb, Croatia; Division of Epidemiology and Prevention of Chronic Noncommunicable Diseases (M Sekerija PhD), Croatian Institute of Public Health, Zagreb, Croatia; Public Health Division (A A Shaheen PhD), An-Najah National University, Nablus, Palestine; Independent Consultant, Karachi, Pakistan, (M A Shaikh MD); Department of Basic Sciences (Prof M Sharif PhD), Department of Laboratory Sciences (Prof M Sharif PhD), Islamic Azad University, Sari, Iran; Policy and Planning Division, Ministry of Health, Thimphi, Bhutan (J Sharma MPH); University School of Management and Entrepreneurship (R Sharma PhD), Delhi Technological University, New Delhi, India; Department of Health Service (S K Sharma PhD), Department of Health, Kathmandu, Nepal; Department of Pulmonary Medicine (J She MD), Fudan University, Shanghai, China; Usher Institute of Population Health Sciences and Informatics (Prof A Sheikh MD, I N Soyiri PhD), University of Edinburgh, Edinburgh, United Kingdom; Friedman School of Nutrition Science and Policy (P Shi PhD), Tufts University, Boston, MA, USA; National Institute of Infectious Diseases, Tokyo, Japan (M Shigematsu PhD); Finnish Institute of Occupational Health, Helsinki, Finland (R Shiri PhD); Washington State University, Pullman, WA, USA (Kawkab Shishani PhD); Symbiosis Institute of Health Sciences (Prof S R Shukla PhD), Symbiosis International University, Pune, India; School of Health (S Siabani PhD), University of Technology Sydney, Sydney, NSW, Australia; Department of Psychology (Prof I D Sigfusdottir PhD), Reykjavik University, Reykjavik, Iceland; Portuguese Institute of Sport and Youth, Lisbon, Portugal (N T d Silva MPsych); Brasília University, Brasília, Brazil (Prof D A Silveira MSc); Max Hospital, Ghaziabad, India (Prof N P Singh MD); Department of Policy Studies (P K Singh PhD), The Energy and Resources Institute School of Advanced Studies, New Delhi, India; Department of Pulmonary Medicine (Prof V Singh MD), Asthma Bhawan, Jaipur, India; Department of Epidemiology (D N Sinha PhD), School of Preventive Oncology, Patna, India; Pediatric Department (B H Sobaih MD), King Khalid University Hospital, Riyadh, Saudi Arabia; Service of Pulmonology (Prof J B Soriano MD), Health Research Institute of the University Hospital "de la Princesa", Madrid, Spain; Division of Community Medicine (C T Sreeramareddy MD), International Medical University, Kuala Lumpur, Malaysia; The Institute of Chartered Accountants of India, Chennai, India (R Srinivasan Bcomm); Department of Occupational Therapy (V Stathopoulou PhD), Athens University of Applied Sciences, Athens, Greece; Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine (N Steckling DrPH), University Hospital Munich, Munich, Germany; Department of Public Health, Health Services Research and Health Technology Assessment (N Steckling DrPH), University for Health Sciences, Medical Informatics and Technology, Hall I T, Austria; Section of Evidence Synthesis and Classification (K Straif PhD), International Agency for Research on Cancer, Lyon, France; Department of Nursing (A Sudaryanto MPH, A Sudaryanto MPH), Muhammadiyah University of Surakarta, Kartasura, Indonesia; School of Medicine (P J Sur MPH), University of California Riverside, Riverside, CA, USA; Department of Criminology, Law and Society (Prof B L Sykes PhD), University of California Irvine, Irvine, CA, USA; Department of Medicine (Prof R Tabarés-Seisdedos PhD), Department of Pediatrics, Obstetrics and Gynecology (Prof M Tortajada-Girbés PhD), University of Valencia, Valencia, Spain; Carlos III Health Institute (Prof R Tabarés-Seisdedos PhD), Biomedical Research Networking Center for Mental Health Network (CiberSAM), MADRID, Spain; Cancer Control Center (T Tabuchi MD), Osaka International Cancer Institute, Osaka, Japan; Africa Health Research Institute, Berea, South Africa (Prof F C Tanser PhD); Department of Psychiatry and Behavioral Sciences (M Tavakkoli MD), New York Medical College, Valhalla, NY, USA; University Institute "Egas Moniz", Monte da Caparica, Portugal (Prof N Taveira PhD); Research Institute for Medicines, Faculty of Pharmacy of Lisbon (Prof N Taveira PhD), University of Lisbon, Lisbon, Portugal; Selihom School of Nursing (N Y Tawye MSc), Alkan Health Science, Business and Technology College, Dessie, Ethiopia; Syrian Expatriate Medical Association, Charlottesville, VA, USA

(A S Terkawi MD); WHO Collaborating Centre for Viral Hepatitis (L A Thomas MPH), The Peter Doherty Institute for Infection and Immunity, Melbourne, VIC, Australia; Department of Global Health Research (A J Thomson PhD), Adaptive Knowledge Management, Victoria, BC, Canada; Agency for Health Technology Assessment and Tariff System, Warszawa, Poland (R Topor-Madry PhD); Pediatric Department (Prof M Tortajada-Girbés PhD), University Hospital Doctor Peset, Valencia, Spain; Department of Health Economics (B X Tran PhD), Hanoi Medical University, Hanoi, Vietnam; Clinical Hematology and Toxicology (K B Tran MD), Military Medical University, Hanoi, Vietnam; National Institute for Research in Tuberculosis, Chennai, India (S P Tripathy MD); CV Medicine (Prof E Tuzcu MD), Cleveland Clinic, Cleveland, OH, USA; CV Medicine (Prof E Tuzcu MD), Cleveland Clinic Abu Dhabi, Abu Dhabi, United Arab Emirates; Department of Internal Medicine (K N Ukwaja MD), Federal Teaching Hospital, Abakaliki, Nigeria; Gomal Center of Biochemistry and Biotechnology (I Ullah PhD), Gomal University, Dera Ismail Khan, Pakistan; TB Culture Laboratory (I Ullah PhD), Mufti Mehmood Memorial Teaching Hospital, Dera Ismail Khan, Pakistan; Argentine Society of Medicine, Ciudad de Buenos Aires, Argentina (Prof P R Valdez M.Ed.); Velez Sarsfield Hospital, Buenos Aires, Argentina (Prof P R Valdez MEd); UKK Institute, Tampere, Finland (Prof T J Vasankari MD); Raffles Neuroscience Centre (Prof N Venketasubramanian MBBS), Raffles Hospital, Singapore, Singapore; Yong Loo Lin School of Medicine (Prof N Venketasubramanian MBBS), National University of Singapore, Singapore, Singapore; Weill Cornell Medicine Department of Pediatrics (R Vidavalur MD), Cornell University, Ithaca, NY, USA; Occupational Health Unit (Prof F S Violante MPH), Sant'Orsola Malpighi Hospital, Bologna, Italy; Department of Health Care Administration and Economy (Prof V Vlassov MD), National Research University Higher School of Economics, Moscow, Russia; Foundation University Medical College (Y Waheed PhD), Foundation University, Rawalpindi, Pakistan; Department of Research (Prof E Weiderpass PhD), Cancer Registry of Norway, Oslo, Norway; Population Studies Center (J Weiss MA), University of Pennsylvania, Philadelphia, PA, USA; Independent Consultant, Staufenberg, Germany (A Werdecker PhD); Department of Neurology (A S Winkler PhD), Technical University of Munich, Munich, Germany; Kailuan General Hospital (Prof S Wu PhD), Kailuan General Hospital, Tangshan, China; Department of Pharmacology (Prof D Xavier MD), St. John's National Academy of Health Sciences, Bangalore, India; School of Medicine (Prof G Xu MD), Nanjing University, Nanjing, China; Clinical Cancer Research Center (S Yahyazadeh Jabbari MD), Milad General Hospital, Tehran, Iran; Duke Global Health Institute (L L Yan PhD), Duke University, Durham, NC, USA; Department of Earth Science (Y J Yasin MPH), King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia; Wolkite University, Wolkite, Ethiopia (A Yeshaneh BHlthSci); University of South Australia, Adelaide, NSW, Australia (B D Yirsaw PhD); Department of Biostatistics (N Yonemoto MPH), Kyoto University, Kyoto, Japan; School of Public Health (M Yotebieng PhD), University of Kinshasa, Kinshasa, Democratic Republic of the Congo; Department of Health Policy and Management (Prof M Z Younis DrPH), Jackson State University, Jackson, MS, USA; Tsinghua University (Prof M Z Younis DrPH), Tsinghua University, Beijing, China; Department of Epidemiology and Biostatistics (Prof C Yu PhD), Global Health Institute (Prof C Yu PhD), Wuhan University, Wuhan, China; Health Care Financing Program (E A Zegeye PhD), Clinton Health Access Initiative, Addis Ababa, Ethiopia; School of Health and Biomedical Sciences (A L Zhang PhD), Royal Melbourne Institute of Technology University, Melbourne, Victoria, Australia; University of Texas, Houston, TX, USA (X Zhang PhD); Israeli Center for Disease Control, Ministry of Health, Ramat Gan, Israel (I Zucker MD); School of Public Health (I Zucker MD), Tel Aviv University, Tel Aviv, Israel.

#### Contributors

Please see appendix 1 for more detailed information about individual author's contributions to the research, divided into the following categories: managing the estimation process; writing the first draft of the manuscript; providing data or critical feedback on data sources; developing methods or computational machinery; applying analytical methods to produce estimates; providing critical feedback on methods or

results; drafting the work or revising it critically for important intellectual content; extracting, cleaning, or cataloguing data; designing or coding figures and tables; and managing the overall research enterprise.

#### Declaration of interests

Ettore Beghi reports personal fees from Market Access Provider and grants from the Italian Ministry of Health, UCB, ALS Association, Eisai, and Shire. Yannick Bejot reports grants and personal fees from AstraZeneca and Boehringer Ingelheim and personal fees from Daiichi-Sankyo, Bristol-Myers Squibb, Pfizer, Medtronic, Bayer, Novex pharma, and Merck. Adam Berman reports personal fees from Philips. Louisa Degenhardt reports grants from Indivior, Mundipharma, and Seqirus. Cyrus Cooper reports personal fees from Alliance for Better Bone Health, Amgen, Eli Lilly, GlaxoSmithKline (GSK), Medtronic, Merck, Novartis, Pfizer, Roche, Servier, Takeda, and UCB. Mir Sohaib Fazeli reports personal fees from Doctor Evidence. Panniyammakal Jeemon reports a clinical and public health intermediate fellowship from the Wellcome Trust-DBT India Alliance (2015–20). Jacek Józwiak reports grants and personal fees from Valeant, personal fees from ALAB Laboratoria and Amgen, and non-financial support from Microlife and Servier. Nicholas Kassebaum reports personal fees and other support from Vifor Pharmaceuticals. Jeffrey Lazarus reports personal fees from Janssen and Cepheid and grants and personal fees from AbbVie, Gilead Sciences, and Merck. Stefan Lorkowski reports personal fees from Amgen, Berlin-Chemie, Merck, Novo Nordisk, Sanofi-Aventis, Synlab, and Unilever, and non-financial support from Preventicus. Walter Mendoza is currently a program analyst for population and development at the Peru Country Office of the UN Population Fund, which does not necessarily endorse this study. Ted Miller reports an evaluation contract from AB InBev Foundation. Constance Dimity Pond reports personal fees from Nutricia advisory board, acting as an unpaid consultant to the Wicking Dementia Research and Education Centre in Tasmania for development of general practitioner (GP) education on dementia (airfares and accommodation paid), payment for acting as a dementia clinical lead and dementia pathways adviser for the Sydney North Primary Health Network, and payment for acting as a GP educator for Presbyterian Aged Care. Maarten Postma reports grants from Mundipharma, Bayer, Bristol-Myers Squibb, AstraZeneca, Artec, and AscA; grants and personal fees from Sigma Tau, Merck, GSK, Pfizer, Boehringer Ingelheim, Novavax, Ingress Health, AbbVie, and Sanofi; personal fees from Quintiles, Astellas, Mapi, OptumInsight, Novartis, Swedish Orphan, Innoval, Jansen, Intercept, and Pharmerit; and stock ownership in Ingress Health and Pharmacoeconomics Advice Groningen. Kazem Rahimi reports grants from National Institute for Health Research Biomedical Research Centre, Economic and Social Research Council, and Oxford Martin School. Miloje Savic is employed by GSK Biologicals. Kenji Shibuya reports grants from Japanese Ministry of Health, Labour and Welfare and Ministry of Education, Culture, Sports, Science and Technology. Mark Shrimme reports grants from Mercy Ships and Damon Runyon Cancer Research Foundation. Jasvinder Singh reports consulting for Horizon, Fidia, UBM, Medscape, WebMD, National Institutes of Health, and the American College of Rheumatology; serving as the principal investigator for an investigator-initiated study funded by Horizon Pharma through a grant to Dinora (a 501C3 non-profit organisation); and being on the steering committee of Outcome Measures in Rheumatology, an international organisation that develops measures for clinical trials and receives arms-length funding from 36 pharmaceutical companies. Jeffrey Stanaway reports a grant from Merck. Cassandra Szoeko reports a grant from the National Health and Medical Research Council (NHMRC), Lundbeck, Alzheimer's Association, and the Royal Australasian College of Practitioners; she holds patent PCT/AU2008/001556. Amanda Thrift reports grants NHMRC. Muthiah Vaduganathan receives research support from the National Heart, Lung and Blood Institute and serves as a consultant for Bayer and Baxter Healthcare. All other authors declare no competing interests.

#### Data sharing

To download the data used in these analyses, please visit the Global Health Data Exchange at <http://ghdx.healthdata.org/gbd-2017>.

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