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REVIEW

Global prevalence of cardiovascular risk factors based on the Life's Essential 8 score: an overview of systematic reviews and meta-analysis

Rubén López-Bueno [1,2,3], Rodrigo Núñez-Cortés [4,5]*, Joaquín Calatayud [2,3], Joaquín Salazar-Méndez[6], Fanny Petermann-Rocha[7,8], José Francisco López-Gil[9], and Borja del Pozo Cruz [10,11,12]

[1]Department of Physical Medicine and Nursing, University of Zaragoza, Zaragoza, Spain; [2]Exercise Intervention for Health Research Group (EXINH-RG), Department of Physiotherapy, University of Valencia, Valencia, Spain; [3]National Research Centre for the Working Environment, Copenhagen, Denmark; [4]Department of Physical Therapy, Faculty of Medicine, University of Chile, Santiago, Chile; [5]Physiotherapy in Motion Multispeciality Research Group (PTinMOTION), Department of Physiotherapy, University of Valencia, Valencia, Spain; [6]Escuela de Kinesiología, Facultad de Salud, Universidad Santo Tomás, Talca, Chile; [7]School of Cardiovascular and Metabolic Health, University of Glasgow, Glasgow, UK; [8]Centro de Investigación Biomédica, Facultad de Medicina, Universidad Diego Portales, Santiago, Chile; [9]One Health Research Group, Universidad de Las Américas, Quito, Ecuador; [10]Faculty of Education, University of Cádiz, Cádiz, Spain; [11]Biomedical Research and Innovation Institute of Cádiz (INiBICA) Research Unit, Puerta del Mar University Hospital, University of Cádiz, Cádiz, Spain; and [12]Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

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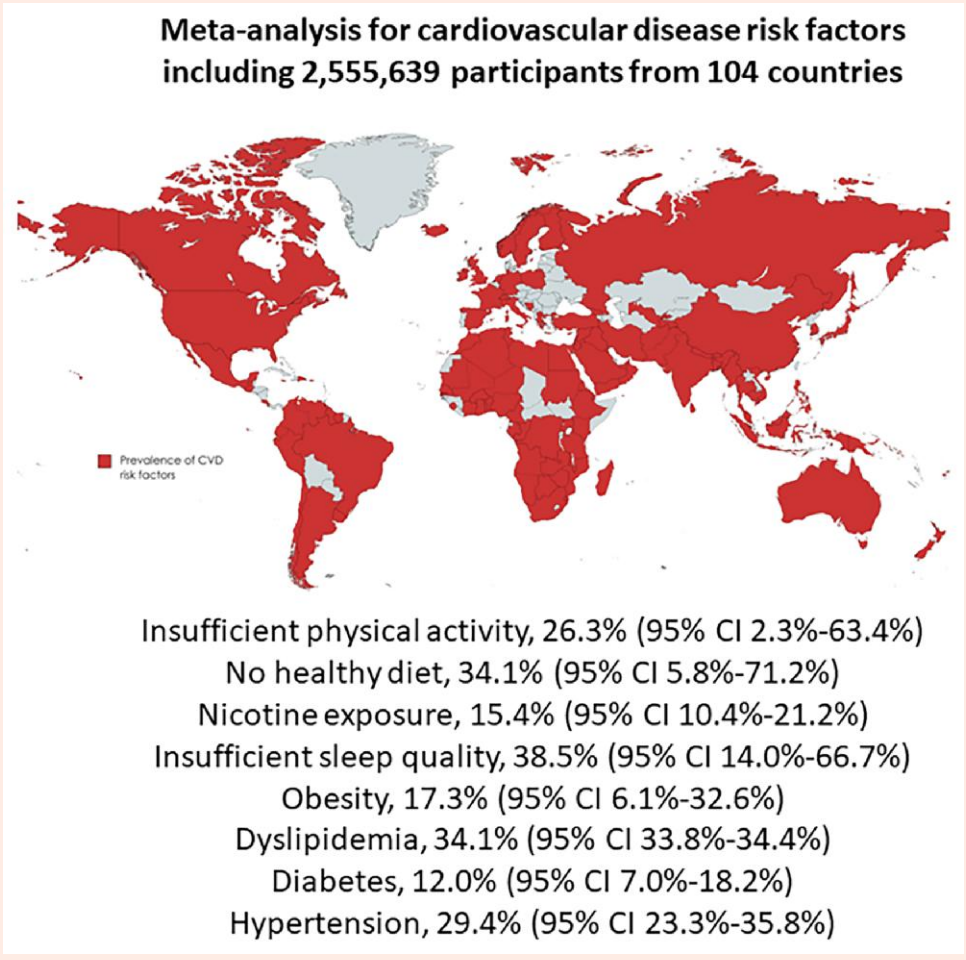
Abstract

Cardiovascular health (CVH) is a critical issue for global health. However, no previous study has determined the prevalence of cardiovascular risk factors based on the American Heart Association's (AHA) Life's Essential 8 (LE8). Therefore, we aimed to estimate the global prevalence of the eight cardiovascular risk factors identified in the LE8. A systematic search of systematic reviews with meta-analysis on cardiovascular risk factors covering data reported between 2000 and 2019 was conducted on PubMed, Epistemonikos, and the Cochrane Library until 1 May 2023. After applying exclusion criteria, 79 studies remained in the final selection for the narrative synthesis in the systematic review, of which 33 of them were used in the meta-analysis which included 2 555 639 participants from 104 countries. The overall pooled prevalence of cardiovascular risk factors was as follows: insufficient physical activity, 26.3% (95% CI 2.3%–63.4%), no adherence to a healthy diet, 34.1% (95% CI 5.8%–71.2%), nicotine exposure, 15.4% (95% CI 10.4%–21.2%), insufficient sleep quality, 38.5% (95% CI 14.0%–66.7%), obesity, 17.3% (95% CI 6.1%–32.6%), dyslipidemia, 34.1% (95% CI 33.8%–34.4%), diabetes, 12.0% (95% CI 7.0%–18.2%), and hypertension, 29.4% (95% CI 23.3%–35.8%). These results warrant prevention strategies aimed at reducing insufficient sleep quality, and no adherence to a healthy diet as leading cardiovascular risk factors worldwide. The high prevalence of hypertension among children and adults is concerning and should also be adequately addressed through global policies.

*Corresponding author. Tel: +562 29786513, E-mail: r_nunez@uchile.cl

Graphical Abstract



Keywords Diet • Physical activity • Nicotine exposure • Sleep

1. Introduction

Cardiovascular diseases (CVD), mainly ischaemic heart disease and stroke, remain the leading cause of death and disability across the world.[1] The number of cases of total CVD increased from 271 million in 1990 to 523 million in 2019, while the number of CVD deaths increased from 12.1 million in 1990 to 18.6 million in 2019.[1] Considering that years lived with disability also rose from 17.7 million to 34.4 million over the same period,[1] CVD continues to place a huge economic burden on global healthcare systems. In this regard, the American Heart Association (AHA) recently published the Life's Essential 8 score (LE8), which updates its recommendations for assessing cardiovascular health (CVH), including the following health behaviours factors and conditions: diet, physical activity, nicotine exposure, sleep health, body mass index, blood lipids, blood glucose, and blood pressure (BP).[2]

Investigating the global prevalence of these eight cardiovascular risk factors is crucial to identify which ones have more significant impact on the global CVH. Early attempts have mainly focused on specific geographical areas, populations, and cardiovascular risk factors.[3–6] Still, studies providing a global prevalence of the eight LE8 cardiovascular risk factors are lacking. One of the most complete studies on the topic examined the global prevalence of nine modifiable cardiovascular risk factors (high systolic BP, high fasting plasma glucose, high low-density lipoprotein cholesterol, high body mass index, impaired kidney function, ambient and house air pollution, smoking, poor diet, and insufficient physical activity);[1] yet, these factors differ from those currently recommended by AHA to monitoring CVH.

Recent research has identified that CVH, according to the LE8 score, is well below optimal in both US children and adults.[7] The same study found an unhealthy diet, insufficient physical activity, and high body mass index as the major contributors to lower LE8 scores.[7] Providing global estimates for the prevalence of cardiovascular risk factors is crucial for informing health policy strategies. This data may help identify groups at higher risk and enable the allocation of appropriate resources to address this significant global public health issue effectively. This study aimed to examine the global prevalence of the eight cardiovascular risk factors identified in the LE8 score during the 2000–2019 period.

2. Methods

This systematic review follows the Cochrane and the Preferred Reporting Items for Overviews of Reviews (PRIOR) guidelines.[8,9] The protocol was pre-registered in the International Prospective Register of Systematic Reviews PROSPERO (registration number: CRD42023422913).

2.1 Eligibility criteria

The following inclusion criteria were considered for the present overview: (i) systematic reviews with meta-analysis; (ii) studies reporting either the prevalence or the proportion of cardiovascular risk factors in humans (children aged 1–17 years and adults aged 18 years and over); (iii) studies conducted between 2000 and 2019 (before the COVID-19 pandemic; (iv) studies with representative samples. To ensure population representativeness and comparability between estimates, a sample size of more than 307 was necessary (calculated using the formula of Naing *et al.*[10]) We also excluded studies conducted in hospitalized or institutionalized people, as well as studies focusing specifically on clinical populations, health conditions, athletes, or single-sex participants. Editorials, letters, reviews, and other observations or experimental studies (either in vivo or in vitro) were not considered.

2.2 Search strategy and study selection

A systematic search was carried out on biomedical and specialized in reviews PubMed, Epistemonikos, and the Cochrane Library databases. Moreover, grey literature was included using Google Scholar and Open Grey until 1 May 2023. Additional studies were also selected from the reference lists of eligible articles and topic-related reviews. All records were analysed using the free web version of Rayyan (http://rayyan.qcri.org). More detailed information on the search strategy is presented in Supplementary material online, *Table S1*.

2.3 Data extraction

After removing duplicate studies, two authors independently extracted data from the selected studies (R.L.B. and R.N.C.) using a standardized protocol and reporting forms. We resolved disagreements by consensus with a third author (B.d.P.C.). From all included studies, we extracted the first author, year of publication of the study, data search, number of studies included, total sample size, country, age group, type of population, risk factor, definition of cardiovascular risk factor, participants with cardiovascular risk factor, and pooled prevalence (95% CI).

If the above data were not included in the article, the corresponding authors of these publications were contacted by e-mail to obtain such information. If information on either definition of cardiovascular risk factors or pooled prevalence was not provided, such studies were removed from the present review. For studies with more than one measurement point, the most recent point was used to ensure the most updated information. For the quantitative synthesis, we selected studies that provided data on the total sample population and number of participants with at least one cardiovascular risk factor. In addition, we included studies that allowed us to determine the prevalence of a cardiovascular risk factor according to LE8 score. When there was no information on the exact cardiovascular risk factor as defined by LE8 score, we used an alternative proxy for the cardiovascular risk factor of interest. The prevalence for each of the eight LE8 cardiovascular risk factors was considered as follows: (i) physical activity (adults: less than 150 min a week; children: less than 60 min a day), (ii) diet (adults and children: healthy diet style), (iii) nicotine exposure (adults and children: current use of cigarettes or inhaled nicotine), (iv) sleep (children and adults: sleep health of the Pittsburgh Sleep Quality Index (PSQI) > 5 points), (v) obesity (adults: body mass index ≥30 kg/m^2; children: body mass index in the 95th percentile according to their reference population), (vi) dyslipidemia (adults and children: one or more abnormal levels of any lipid profile), (vii) diabetes (adults and children: fasting blood glucose 126 mg/dL), and (viii) hypertension (adults: systolic BP or diastolic BP ≥140/90; children: systolic BP and/or diastolic BP according to the 95th percentile of their reference population), unless other prevalence outcomes stated.

2.4 Quality assessment

Quality assessment was performed independently by three reviewers (R.N.C., J.C., and J.S.M.), and disagreements were resolved by consensus with a fourth reviewer (R.L.B.). The quality of included studies was assessed using the AMSTAR 2, a tool to assess the methodological quality of a systematic review comprising 16 items.[11] The specific questions in AMSTAR 2 are worded so that a 'yes' response indicates a positive outcome. If no information is provided to assess an item, it should be assessed as 'no'. In addition, the tool includes a 'partial yes' in some cases where it identifies partial compliance with the standard.

2.5 Data synthesis

We first conducted a narrative review to summarize the selected studies' characteristics. When available, we extracted raw data on sample size and the number of cases with each of the examined cardiovascular risk factors from eligible studies. When there was no data on sample size or number of cases with any cardiovascular risk factor, we calculated these by either retrieving data from original articles or multiplying the given study prevalence by the sample size. To avoid the risk of overlapping prevalence data from a country derived from two or more studies included in the quantitative analyses, we removed older studies with potential repeated data or specific data for any country. We removed the study with a smaller sample size for studies from the same country and the same date for data origin.

2.6 Statistical analyses

Stata 16.1 (StataCorp, TX, USA) with the *metan* user command was used to pool data from eligible studies using the DerSimonian and Laird random-effects procedure.[12] We also used the Clopper-Pearson method to determine 95% CIs for prevalence from the selected individual studies.[13] We conducted a Freeman-Tukey double arcsine transformation, which has shown higher reliability and accuracy than other transformation procedures, to stabilize the variances before calculating the pooled prevalence.[14] The results were displayed as forest plots. We used Higgin´s I^2 statistics to assess heterogeneity between studies. Based on I^2, heterogeneity was classified as negligible ($I^2 = 0\%–40\%$), moderate ($I^2 = 30\%–60\%$), substantial ($I^2 = 50\%–90\%$), or considerable ($I^2 = 75\%–100\%$). To assess potential small-study effects due to publication bias, we used the Luis Furuya-Kanamori (LFK) index and the Doi plot.[15]

When cardiovascular risk factors were reported in three or more studies, we conducted leave-one-out meta-analyses, which showed the influence of each individual study on the overall prevalence estimate of the rest of the studies and the potential distort of the overall results. Thereafter, we conducted sensitivity analyses by removing the most influential study of each examined cardiovascular risk factor.

3. Results

3.1 Study selection

The initial database search yielded 710 records. After removing 68 duplicates, 642 potentially eligible studies were identified from the initial electronic searches. After screening publications by title and abstract, 113 potentially eligible studies were retrieved for inclusion and full-text articles. Additionally, 14 articles were identified by citation searching using the grey literature. After applying exclusion criteria, 79 studies[3–6,16–89] remained in the final selection for the narrative synthesis (see Supplementary material online, *Figure S1*). Of these, 33[3,4,6,17,20,22,25,27,28,30,34–36,38,39,41–43,48–50,54,55,57,60,61,66,68,70,71,78,82,90] studies were used in the meta-analysis of prevalence after removing studies due to either overlapping risk or containing any data before 2000. The characteristics of the included studies are shown in *Table 1*.

3.2 Study characteristics

Figure 1 illustrates the countries with available prevalence data for the cardiovascular risk factors investigated. We detected a lack of data, particularly in Eastern Europe, Caribbean countries, Central America, Central South America, Central Africa, and Central Asia. The retrieved age of participants ranged from less than 1 to 78 years, and the sample size of the included

Table 1 Description of included meta-analyses

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Abubakari 2008[46]	1996 to March 2007	18 (2000–2004)	48 690	West Africa (Cameroon, Gambia, Ghana, Nigeria, Senegal and Sierra Leone)	15 years and over	Urban and rural	Obesity	BMI >=30	4869 (estimated)	10.0 (6.0–15.0)
Abubakari 2009[57]	1996 to March 2007	Diabetes: 3 (2000 onwards) PA:5 (2003)	Diabetes: 13 548 PA: 8425	Diabetes: West Africa (Cameroon, Nigeria) PA:West Africa (Burkina Faso, Cote d'Ivoire, Ghana, Mali, Senegal)	18 years and over	Urban and rural	Diabetes Physical activity	WHO´s definition of diabetes (FBG>=6.1 or casual plasma glucose >=7.0 then 75 g oral glucose tolerance test>=111) PA: (<150 min/week)	Diabetes: 542 (estimated) PA: 1095 (estimated)	Diabetes:4.0. (2.0–9.0) PA 13.0 (9.0–18.0)
Adeloye 2015[79]	January 1980 to December 2013	6(2005–2013)	NR	Nigeria	Mean: 46.9	Rural	Hypertension	SBP at least 140 mmHg and/or DBP at least 90 mmHg	NR	26.4 (19.4–33.4)
Adeloye 2019[68]	1990 through 2018	9(2015)	103 588(estimated)	Nigeria	15 years and over	General	Nicotine	Tobacco products consumption (smoking every day, or some days in the last 30 days preceding an interview)	10 980	10.4 (9.0–11.7)
Adeloye 2021 A[88]	From 01 January 1990 onwards	35	103 138 833 (2020)	Nigeria	15 years and over	Urban and rural	Obesity	BMI >=30	11 992 676 (2020)	14.3 (12.0–15.5)
Adeloye 2021 B[89]	January 1990 onwards	53	77 862 890 (2020)	Nigeria	20 years and over	Urban and rural	Hypertension	(≥140/90 mmHg)	27 485 600 (2020)	32.5 (29.8–35.3).
Adnan 2020[16]	Between October 2018 and March 2019	12 (3 studies before 2000)	42 051	Pakistan	20 years and over	General population	Diabetes	OGTT (5), BSF (4), HbA1c (2), BSR (1) WHO criteria (8), and ADA criteria (4)	5761(estimated)	13.7 (10.7–17.3)
Afsargharehbagh 2019[17]	From inception until 30 August 2018	48	417 392	Iran	15–69y	General population	Hypertension	(≥140/90 mmHg) (47), (≥130/ 90 mmHg) (1)	85 148(estimated)	20.4 (16.5–24.4)
Aiello 2015[18]	01 January 2008 to 31 May 2014	21 (2008–2014)	18 463	Brazil	Children and Adolescents	General population in Brazil	Obesity	BMI ≥ 95th percentile for sex/age	2608 (estimated)	14.1 (10.6–18.1)
Akbari 2017[19]	Up to 30 September 2015	17	79 231	Iran	3–18y	General population of children and adolescents	Hypertension	Average SBP and/or DBP >= 95th percentile for sex, age, and height	7052 (estimated)	8.9 (7.5–10.3)
Akthar 2021	From inception to April 2020	6 (2012–2017)	7071	Afghanistan	18 years and over	Urban	Diabetes	FBG>=126 mg/dL	889	12.1 (8.9–16.2),
Akhtar 2020	Between 1st of January 1995 and 31st of August 2019	12 (2011–2019)	40 402	Bangladesh	18 years and over	General population	Diabetes	FBG>=7 mmol/L and/or 2hBG ≥11.1 mmol/L	4202 (estimated)	10.4 (8.7–12.4)
Alharbi 2014[21]	from 1st January 1979 to 31st December 2011	Diabetes:21 Obesity:12	NR	Arabian Gulf States (Saudi Arabia and Kuwait)	18 years and over	General population	Diabetes (Pooled Type 1 and 2) Obesity	Diabetes: WHO, OGTT, or ADA criteria Obesity: BMI >=30 kg/m2	NR	Diabetes: 27.0 (Saudi Arabia) (2011) Obesity:NR
Almahmoud 2022[22]	From 2011 to 2021	14	14 024	Arab countries (Palestine, Saudi Arabia, Algeria, Egypt, Lebanon, Morocco, Tunisia, Iraq, and United Arab Emirates)	10–19 y.	Adolescents	Hypertension	SBP or a BP>=95th percentile by sex, age, and height	2147	12.6 (8.3–17.6)
Anchala 2014[23]	From 1950 to 30 April 2013	13(2011–2013)	53 976	India	18 years and over	General population	Hypertension	>=140 SBP and or >=90 DBP	16 892	31.3 (estimated)
Atibila 2021[24]	Up to November 2020	24(2004–2020)	30 033	Ghana	5 years and over	Urban and rural	Hypertension	>=140 SBP and or >=90 DBP	10 011	30.0 (26.0–35.0)
Baldoni 2019[25]	Up to December 2017	21(2001–2015)	7730	Brazil	18 years and over	Indigenous	Obesity	BMI >=30 kg/m2	1709	17.0 (13.0–23.0)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Bao 2020[26]	Up to 20 September 2019	9(2006–2015)	3 258 966	China	18 years and over	General population	Hypertension	>=140 SBP and or >=90 DBP, and/or use of antihypertensive medicine within 2 weeks	997 244	30.6 (26.0–35.1)
Barufaldi 2012[27]	Up to August 2010	15 (2002–2007)	30 879	Brazil	10–19 years	Adolescents	Physical activity	<300 min/week	15 440(estimated)	50.0 (estimated)
Bosu 2021[28]	Up to April 2020	85(2003–2020)	84 184	Ghana	15 years and over	General population	Hypertension	>=140 SBP and or >=90 DBP, and/or use of antihypertensive medicine	22 730(estimated)	27.0 (24.0–30.0)
Caleyachetty 2015[3]	2003–2011	65	169 369	65 Low-to Medium Income countries	13.9(SD 0.3)	Adolescents	Nicotine Diet Obesity Physical activity	Nicotine:smoked any cigarette or used other tobacco products during the past 30 days Diet: intake of fruit and vegetables less than five times per day Obesity:>2 SD of the median for age and sex based on the 2007 WHO Child Growth PA: Having < 5 days/week of at least 60 min per week	Nicotine: 20 494 (estimated) Diet: 90 177 (estimated) Obesity:12 025 (estimated) PA: 86 658 (estimated)	Nicotine:12.1 (10.2–14.1) Diet:74.3 (71.9 – 76.5) Obesity: 7.1 (5.6–8.7) PA: 71.4 (69.5–73.3)
Cao 2017[29]	Inception to 10 April 2016	17 (2003–2016)	115 988	China	Adults	General population	Sleep	PSQI > 7 (10) AIS > 6 (2) Standarized questions (5)	PSQI: 7878/67 489 AIS: 2300/10 535 Standarized questions: 4085/37 964	PSQI 15.1 (14.4–19.6) AIS 22.3 (20.4–24.4) Standarized questions 12.5 (8.1–18.9)
Castrillon 2020[30]	From inception to 25th March 2019	28(2004–2017)	318 032	Australia	18 years and over	Rural adults	Physical activity	<150 min/week	12 721 (estimated)	4.0 (0.4–8.0)
Chen 2014a[31]	From 1 January 2004 to 31 December 2013	109	1233 079	China	18 years and over	Rural	Hypertension	>=140 SBP and or >=90 DBP	319 503	25.9 (estimated)
Chen 2014b[32]	Between 1980 and 2012	27 (2000–2012)	104 692	China	15 years and over	Islanders and people living in coastal areas	Hypertension	>=140 SBP and or >=90 DBP, and/or use of antihypertensive medicine	31 408(estimated)	30.0 (26.7–33.6)
Chen 2021[33]	From inceptionuntil December 2020	66	188 809	China	<=14 years	Mainland children	Sleep	CSHQ, ICSD (Snoring, choking, gasping, apnoea, restless sleep, mouth breathing, hyperhidrosis, leg movements, bruxism, sleep talking, sleep-walking nightmares, enuresis, night awakening, and trouble falling asleep)	70 992(estimated)	37.6 (34.3–40.9)
Chinnaiyan 2022[34]	Between January 2000 and December 2020	33(2004–2020)	35 985	India	12 years and over	Tribal population	Diabetes	NR	2159 (estimated)	6.0 (5.0–7.0)
Chowdhury 2020[35]	From inception to 13 May 2019	37(2001–2019)	202 162	Bangladesh	18 years and over	Healthy general population	Hypertension	>=140 SBP and or >=90 DBP, and/or use of antihypertensive medicine	46 497 (estimated)	23.0 (21.0–24.0)
Chukwuonye 2022[36]	From 1 January 2010 to 31 December 2020	33	37 205	Nigeria	18 years and over	General population	Obesity	BMI >=30 kg/m2	5 378	14.5 (11.8–17.4)
Dang 2022[37]	From inception to July 2021	12(2004–2019)	15 861	Vietnam	>15 years	Healthy general population	Dyslipidemia	Low HDL-C (IDF, NCEP/ATP III, AHA/NHLBI, and modifications)	21 270 (estimated)	34.1 (26.0–42.1)
Defo 2019[55]	Up to 30 November 2018	10 (2011–2018)	24 774 (obtained from primary studies)	Cameroon	Adults	Community dwellers	Hypertension	SBP at least 140 mmHg or DBP at least 90mmHg	7959 (estimated)	32.1 (27.2- 37.1)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Dhungana 2021[38]	NR	5(2016–2020)	34 229	Nepal	15 years and over	Rural and urban	Hypertension	>=140 SBP and or >=90 DBP, and/or use of antihypertensive medicine	10 269(estimated)	32.0 (23.0–40.0),
Fatema 2016[4]	Up to August 2014	8 (2006–2012)	70 242	Bangladesh	18 years and over	General population	Dyslipidemia	Dyslipidemia: TG ≥ 1.70, HDL <1.04 for men and <1.29 for women, TG ≥ 1.7, HDL <1.03 for men and <1.29 for women, high cholesterol > 240 mg/dL, high LDL > 160 mg/dL, Low HDL <40 mg/dL, high TG ≥200 mg/dL and total Chol/total HDLC (>5.5), High cholesterol >200 mg/dL, Low HDL <40 mg/dL, High TG ≥150 mg/dL, self-reported, or not specified	23 882(estimated)	34.0 (25.0–41.0)
Ferreira 2021[39]	Up to September 2019	20 (2010-onwards)	14 669	Brazil	0–9 years	Children	Obesity	0–5 years: BMI ≥ 95th percentile for sex/age 6–9 years: Z-score +2SD for sex/age	1760 (estimated)	12.0 (11.5–12.6)
Filho 2015	Between August and October 2014	23 (1975–2014)	13 811	Brazil	Without age restriction	Indigenous populations in Brazil	Hypertension	Non-specific	856 (estimated)	6.2 (3.1–10.3)
García 2015	Until January 2014	17 (2004–2014)	Chile:799 Cyprus:904 Greece:6738 Italy:6809 Spain:11 732 Turkey:890	Chile Cyprus Greece Italy Spain Turkey	2–25 years	Young population	Diet	KIDMED ≤3 points	Chile:233 Cyprus:355 Greece:2673 Italy:861 Spain:720 Turkey:159	Chile:29.0 (26.0–32.0) Cyprus: 39.7 (estimated) Greece: 39.7 (estimated) Italy: 12.6 (estimated) Spain:6.0 (estimated) Turkey:18 (15.0–21.0)
Gonçalves 2016[42]	NR	22(2003–2011)	14 115	Brazil	10-years	Schooled adolescents	Hypertension	10–17 years: >=95th percentile for sex, height and age 18–19 years: > 140 SBP and >90 DBP(mmHg)	1129(estimated)	8.0 (5.0–11.0)
Hajri 2021[43]	Up to February, 2018	33	<5years: 10 542 5–11 years:13 581 12–18 years: 15 843 >=19 years: 91 079	Ecuador	From <5 to >65 years	General population	Obesity	<=18 years:> 2 SD in BMI-for-age>=19 years: BMI >=30 kg/m2	<5years: 841 5–11 years:1294 12–18 years: 1671 >=19 years: 40 282	<5years:8.1 (6.9–9.3) 5–11 years: 10.7 (9.6–11.7) 12–18 years: 10.5 (9.2–11.9) >=19 years: 44.2 (43.1–45.4)
Hazarika 2022[44]	NR	27(2004–2021)	35 297	India	15 years and over	Tribal population	Diabetes	FBG ≥126 mg/dLb, FPG ≥ 126 mg/dLc, IFG ≥126 mg/dLb, RBG ≥200 mg/dLc, 2 h OGTT ≥200 mg/dLb	1730(estimated)	4.9 (4.7–5.2)
Huang 2019[45]	From January 2000 to August, 2018	23(2006–2018)	99 792	Nepal	15 years and over	General population	Hypertension	BP ≥140/90 mmHg and/or the use of antihypertensive medication	27 243(estimated)	27.3 (23.8–30.9)
Jafari 2021[47]	From January 2010 to April 2020	84	16 291 712	Worldwide	11 years and over	Women only	Nicotine	Current cigarette smoking (self-reported)	2 796 591	17.0 (14.0–19.0)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Jarrar 2023[48]	2000–2020	19	258 283	Saudi Arabia	1 year and over	General population	Diabetes	NR (levels)	42 358(estimated)	16.4 (11.6–17.5)
Kassie 2020[49]	From 1 January 2010 to 10 March 2020	16	19 527	Ethiopia	NR	General population	Obesity	BMI >=30 kg/m2	1054(estimated)	5.4 (4.4–6.5)
Kayıkçıoğlu 2018[50]	15 years backwards	7	50 451	Turkey	18 years and over	General population	Dyslipidemia	Hypertriglyceridemia: > 150 mg/dL	17 307	36.5 (30.6–42.5)
Kaze 2017[51]	Between 1 January 2000 and 05 March 2016	91 (2004–2016)	54 198	Nigeria, Ethiopia, Tanzania, Seychelles, Burkina Faso, South Africa, Uganda, Ghana, Tunisia, Cameroon, Algeria, Kenya, Madagascar, Togo, Botswana, Senegal, Zimbabwe, Sudan, Benin, Eritrea, Namibia, Malawi, Morocco, Congo, Ivory Coast, Democratic Republic of Congo, Gabon, Mauritania, Mozambique, Niger, Egypt, and Libya	Individuals aged 55 years or older	Population-based in a sub-Saharan or North African country	Hypertension	140 (SBP) and/or 90 mmHg (DBP) and/or treatment with antihypertensive medications.	29 917	55.2 (53.1–57.4)
Khonsari 2021[52]	Inception to 21 October 2020.	178 (1992–2020)	2 262 797	United Arab Emirates, Yemen, Palestine, Qatar, Syria, Tunisia. Lebanon, Morocco, Oman, Jordan, Saudi Arabia, Iraq, Iran, Algeria, Israel, Egypt	Adults and older adults	Middle East and North Africa	Hypertension	Self-reporting	588 327 (estimated)	26.0 (25.0–27.0)
Kocevska 2021[53]	9 August 2019	Sleep duration (1993–2015) Poor quality: 14 (1997 to 2011)	Sleep duration 3–5 yrs: 1266 6–13 yrs: 8377 14–17 yrs: 513 18–25 yrs: 5 192 26–40 yrs: 38 635 41–64 yrs: 93 837 >65 yrs: 8195 Poor quality: 6 to 13 y: 4790 14 to 17 y: 1211 18 to 25 y: 2005 26 to 40 y: 25 177 41 to 65 y: 64 128 >65 years: 7467	Netherlands, United Kingdom, and United States	Older than 1 year	General population	Sleep	Sleep duration according to the recommendations of the American National Sleep Foundation by age (sleeping less) Poor quality: self-reported	NR	Sleep duration: 3–5 yrs: 1.0 6–13 yrs: 5.4 14–17 yrs: 51.5 18–25 yrs: 14.3 26–40 yrs: 20.1 41–64 yrs: 27.8 >65 yrs: 35.4 Poor quality: 6 to 13 y: 3.3 14 to 17 y: 6.4 18 to 25 y: 13.2 26 to 40 y: 13.4 41 to 65 y: 12.9 >65 years: 15.0
Kolahdooz 2017[54]	January 1990 - June 2013	Nonadults: 2 (After 2005) Adults: 6 (After 2005)	Nonadults: 661 Adults: 8409	Canada	Nonadults (<18 y) Adults	Indigenous populations	Obesity	Nonadults: BMI ≥ 95th percentile Adults: BMI ≥ 30 kg/m^2	Nonadults: 171 Adults: 3523	Nonadults: 25.8 (22.8–28.8) Adults: 41.9 (35.7–48.0)
Liu 2016[56]	1 January 2010 to 20 June 2016	7 (2011–2016)	109 718	China	Adults	Rural population	Diabetes	Non-specific	10 260	7.3 (5.3–9.4)
Ma 2013[58]	January 2002 - June 2012	27 (2002–2010)	195 027	China	Age ≥15 years	The general population in Chinese Cities	Hypertension	SBP ≥ 140 mmHg, DBP ≥ 90 mmHg, or self-reported current treatment with an antihypertensive	41 931 (estimated)	21.5 (19.4–23.6)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Magliano 2013[59]	1990 to September 2010	17 (1996 -2010)	14 636	Brazil	Adolescents	General population	Hypertension	Values greater than or equal to the 95th percentile	1188 (estimated)	8.1 (6.2–10.5)
Manzar 2020[60]	NR	9 (2012 -2018)	9103	Ethiopia	Adolescent and adult populations	Community or facility-based sample.	Sleep	PSQI scores of 5 and above	4824 (estimated)	53.0 (42.0–63.0)
Medrano 2005[5]	1990–2003	27 (1992–2003)	General populatio65 397 (obtained from primary studies)	Spain	Children and adults	General population	Nicotine Dyslipidemia Hypertension Obesity Diabetes	Nicotine:current smoking Dyslipidemia: hypercholesterolemia (total cholesterol > 250) Hypertension:(>140/90 mmHg) Obesity: (BMI > 30) Diabetes: (Basal blood glucose > 126 mg/dL)	NR	Smoking Women: 24.1 (21.7–26.6) Men: 40.7 (37.5–44.0) Hypercholesterolemia Women: 20.1 (16.3–23.9) Men: 20.4 (16.2–24.5) Hypertension Women: 31.8 (24.5–39.0) Men: 35.6 (27.0–44.3) Obesity Women: 23,5 (19.1–27.9) Men: 17.8 (15.1–20.5) DM Women: 7.9 (6.9–8.9) Men: 12.5 (11.0–14.1)
Nawi 2021[61]	January 2015 to April 2020	Adults: 6 (2016–2019) Children and adolescents: 2 (2018–2019)	Adults: 36 724 Children and adolescents: 906	Adults: Malaysia Myanmar Singapore Indonesia Philippines Children and adolescents: Malaysia	Adults (>15–64) Children and adolescents	Adults: community setting Children and adolescents: school setting	Hypertension	Adults: SBP ≥140 mmHg and/or diastolic BP ≥ 90 mmHg or the participants reported a history of hypertension/medications Children and adolescents: SBP and/or DBP above or equal to the 95th percentile for sex, age, and height	Adults: 12 478 (estimated) Children and adolescents: 296 (estimated)	Adults: 34–0 (33.5- 34.5) Children and adolescents: 32.7 (30.5–38.8)
Neupane 2014[62]	1 January 2000 to 30 September 2013	33 (2001–2013)	220 539	Bangladesh Bhutan India Maldives Nepal Pakistan Sri Lanka	Adolescent and adults	General population	Hypertension	SBP at least 140 mmHg or DBP at least 90 mmHg or medicine	59 744 (estimated)	27.1 (22.3–31.9)
Noubiap 2022[63]	up to 23 May 2021	Central Obesity:209 High BP: 22 High Blood glucose: 212	Central Obesity: 2 416 180 High BP: 39 297 High Blood glucose: 2 594 478	Multi-country	Adults	General population	Obesity Hypertension Diabetes	Obesity: Central Obesity (ethnicity-specific): NR Hypertension: High BP: ≥ 140/90 mmHg Diabetes: FPG ≥ 5.6 mmol/L.	Central Obesity: 1 089 679 (estimated) High BP: 13 715 (estimated) High Blood glucose: 635 647 (estimated)	Central Obesity: 45.1 (42.1–48.2) High BP: 34.9 (27.4–42.8) High Blood glucose: 24.5 (22.5–26.6)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Paiva 2023[64]	May 2020 to July 2021	8	NR	Brazil	Adolescents	General population	Obesity Hypertension Diabetes	Obesity: abdominal obesity Hypertension: NR Diabetes: NR	NR	Obesity: 11.0 (8.1–14.9) Hypertension: 10.3 (7.8–13.5) High blood glucose: 9.0 (5.0–14.0)
Peng 2018[65]	1 January 2010 to 30 June 2018	28 (2011–2018)	NR	US China Ecuador Canada Spain South Korea Luxembourg Brazil Republic of Srpska Bosnia and Herzegovina Iran Finland Ireland Iceland France Israel Uganda Northern Ireland India Italy Poland UK Peru Chile Australia Argentina Uruguay	Adults	General population	Nicotine Physical activity Diet Dyslipidemia Hypertension Diabetes	Ideal metrics Smoking Never or quit >12 months Physical activity >150 min/week moderate intensity or >75 min/week vigorous intensity or ≥150 min/week moderate + vigorous Dietary pattern 1) Fruits and vegetables: ≥ 4.5 cups per day 2) Fish: ≥ 4.5 cups per day 3) Fibre-rich whole grains (≥1.1 g of fibre per 10 g of carbohydrate): ≥three 1-oz-equivalent servings per day 4) Sodium: ≥ 4.5 cups per day 5) Sugar-sweetened beverages: < 450 kcal (36 oz) per week TC <200 mg/dL, untreated BP <120/80 mm Hg, untreated FPG <100 mg/dL, untreated	NR	Smoking 72.0 (65.7–71.4) Physical activity 44.5 (34.2–54.9) Dietary pattern 11.3 (10.6–11.9) TC 54.1 (43.3–65.0) BP 37.6 (31.2–44.1) FPG 69.3 (58.5–80.1)
Peng 2022[66]	NR	Hypertension 8 (After 2015) Diabetes 13 (2014–2020)	Hypertension 20 625 Diabetes: 54 137	China	Adults	Tibetan population	Hypertension Diabetes	Hypertension: SBP or DBP ≥140/90 mmHg, and/or a history of hypertension, and/or reported current treatment with antihypertensive medications. Diabetes: self-reported, and/or FPG ≥ 7.0 mmol/L, and/or 2-h plasma glucose ≥ 11.1 mmol/L.	Hypertension: 5940 (estimated) Diabetes: 4060 (estimated)	Hypertension: 28.8 (21.8–35.9) Diabetes: 7.5 (5.2–9.8)
Qi 2015[67]	January 2009 and June 2014	18 (2009–2014)	247 547	China	Age range: 5–14	Primary students	Obesity	BMI (cut-off point not reported)	26 466	10.0 (7.2–13.5)
Rizwan 2014[6]	1981 to 2011	20 (1982–2011)	64 674	India	Adults (>14)	Indian Tribes	Hypertension	Different cut-off points(140/90 or 160/95 mmHg)	10 412	16.1 (13.5- 19.2)
Ruiz-Alejos 2021[69]	Up to n 14 January 2021.	15 (1999–2020)	161 195	Perú	Adults	General Population	Hypertension	According to the Joint National	35 463	22,0 (20.0- 25.0)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
								Committee criteria's (measurement, self-report of disease, and/or antihypertensive treatment).		
Serhier 2018[70]	NR	Tunisia 8 (2002–2016) Morocco 4 (2009–2012) Algeria 6 (2007–2018)	Tunisia 33 396 Morocco 18 390 Algeria 7818	Tunisia, Morocco, and Algeria	Min-max: 11–20 years	General Population	Nicotine	Current smoking	Tunisia 8477 Morocco 3085 Algeria 1470	Tunisia 25 (21–29) Morocco 16 (14–18) Algeria 14 (8 -22)
Shah 2018[71]	NR	7 (2010–2017)	19 682	Pakistan	Adults (≥15 years)	Urban and Rural	Hypertension	≥140/90 mmHg	5895 (estimated)	30.0 (24.1–35.8)
Simonelli 2018[72]	Inception to the end of January 2017	Adults 19 (2005–2017) Older adults 19 studies/26 size effects (2002–2016) PSQI Only 14 (2009–2017)	Adults 124 411 (obtained from primary studies) Older adults 105 548 (obtained from primary studies) PSQI Only 38 567 (obtained from primary studies)	Adults Argentina, Brazil, China, Georgia, Ghana, India, Iran, Pakistan, Turkey Older Adults: Brazil, China, Dominican Republic, Ecuador, India, Iran, Mexico, Peru, Puerto Rico, Russia, South Africa, Venezuela PSQI Only Argentina Brazil China Ecuador Georgia Iran	Adults (aged 16 years old and above)	General population in LMIC	Sleep	PSQI (>5, > 7, or >10) and single item, questionnaire.	Adults 40 806 (estimated) Older adults 35 253 (estimated) PSQI Only: 18 010 (estimated)	Adults 32.8 (25.9–39.7) Older adults 33.4 (26.4–40.1) PSQI Only: 46.7 (33.5 -60.0)
Song 2019[73]	Inception to June 2018	16 (2010–2014)	41 707	India, Brazil, Italy, Nigeria, China, Iran, Poland, USA (obtained from primary studies)	Children or adolescents (≤19 years of age)	General Population	Hypertension	SBP and/or DBP ≥ 95th percentile (for age, sex, and height) on ≥3 separate occasions	2671	6.0 (4.4–7.9)
Sousa 2016[74]	2006 to 26 February 2015	4 (2006–2014)	2485 (obtained from primary studies)	Brazil	Children	Population-based.	Overweight/obesity	BMI for age > 2 or ≥ 2 Z-scores	191 (estimated)	7.7
Tabatabaei-Malazy 2014[75]	Up to September 2011	Hypercholesterolemia: 14 (1994- 2008)	Hypercholesterolemia: 1 134 874	Iran	≥15 years	General population	Dyslipidemia	Hypercholesterolemia (≥200 mg/dL)	Hypercholesterolemia: 472 107 (estimated)	Hypercholesterolemia: 41.6 (36.1-47.0)
Toori 2018[76]	From October 1998 until January 2016	Hypercholesterolemia: 31 (2000–2015) High LDL-C: 21 (2000–2013) Low HDL-C: 17 (2003–2015)	NR	Iran	≥20 years	General population	Dyslipidemia	Hypercholesterolemia: ≥ 200 mg/dL High LDL-C: ≥ 130 mg/dL and ≥160 mg/dL Low HDL-C: < 40 mg/dL)	NR	Hypercholesterolemia: 42 (38–45) High LDL-C: 40 (32–48) Low HDL-C: 42 (35–50)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
Uthman 2022[77]	Inception to December 2020.	Hypertension: 33 (2011–2020) Blood glucose: 22 (2011–2020)	NR	India, Bangladesh, Nepal, and Pakistan, Kenya, Nigeria, Brazil, Peru, Thailand, Kibera, Delhi, Hyderabad, Ajegunle, Chandigarh, Chennai, Dhaka, Haryana, and Maceio.	Adult population (18 years and above)	Slum residents	Hypertension Diabetes	Hypertension: SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg Diabetes: FBG was ≥126 mg/dL (≥7.0 mmol/L) after an overnight fast for at least 8 h, or random capillary blood glucose of ≥11.1 mmol/L or taking treatment for T2DM.	NR	Hypertension: 24.7 (21.0 to 28.6) Diabetes: 10.2 (7.4–13.4)
Wang 2019[78]	1 January 2010 to 4 May 2018	14 (2006–2014)	75 821 (obtained from primary studies)	China	Unspecified (range ≥12 to 99 years)	Rural area	Sleep	PSQI (>5, ≥ 7 or >7)	18 955 (estimated)	25.0 (18.8–31.2)
Xiong 2021[80]	14 December 2017, to 30 September 2019	25 (≥2010)	1 797 088	USA, South Korea, Nigeria, Nepal, Switzerland, Bangladeshi, India, Iran, Canada, Spain, Peru, Mexico, Vietnam, Italy, Germany, Venezuela, China	Adults	General population	Hypertension	2017 ACC/AHA guideline	917 773 (estimated)	51.1 (44.4–57.8)
Yammine 2017[81]	Inception to May 2015	2 (1996–2008)	1681	United Arab Emirates	Young population	General population	Physical activity	No practice of physical activity (Non-specific)	407 (estimated)	24.2 (22.2–26.3)
Yoong 2018[82]	Inception to December 2015	Canada 2 (2013–2015) Greece 1 (2015) Iceland 1 (2015) Ireland 1 (2015) Italy 3 (2013–2015) New Zealand 2 (14) Poland 1 (2013–2014) UK 3 (2013–2014) US 8 (2013—2015)	Canada 19 478 Greece 1320 Iceland 3477 Ireland 821 Italy 476 New Zealand 3018 Poland 1970 UK 42 707 US 109 489	Canada, Greece, Iceland, Ireland, Italy, New Zealand, Poland, UK, US	Young people aged ≤20 years	General population	Nicotine	Use of electronic nicotine delivery systems	Canada 3706 Greece 219 Iceland 587 Ireland 196 Italy 29 New Zealand 604 Poland 1223 UK 4592 US 15 671	Canada 19.0 (18.4–19.5) Greece 16.6 (14.6–18.7) Iceland 16.9 (15.7–18.2) Ireland 23.9 (21.0–26.9) Italy 5.9 (3.3–9.2) New Zealand 19.9 (18.5–21.3) Poland 62.1 (59.9–64.2) UK 9.2 (7.2–11.3) US 17.3 (10.3–25.7
Zabetian 2014[83]	January 1990 - January 2012.	109 (1990–2012)	1 100 746	Multi-country	NR	Rural population	Diabetes	WHO criteria or American Diabetes Association guidelines	74 851 (estimated)	6.8 (6.1–7.6)
Zeng 2016[84]	Inception to January 2015	46 (1997–2015.)	381 580	China	Aged 15 years and older	Community population	Nicotine	Non-smoker are exposed to another person's tobacco smoke for at least 15 min daily for more than 1 day per week.	185 829 (estimated)	48.7 (44.8–52.5)
Zeng 2020[85]	Inception to 16 April 2019	13 (1994–2017)	326 908	Korea, China, US, Norway, Spain, Canada, Nigeria, Germany	NR (mean age ranged	General population	Sleep	International diagnostic criteria, such as the DSM, ICSD, and ICD systems;	71 919 (estimated)	22.0 (17.0–28.0)

Continued

Table 1 *Continued*

First author (year)	Data search	Number of studies included (years)	Total sample size	Country	Age group	Type of population	Risk factor	Definition of risk factor	Participants with risk factor (N)	Pooled prevalence (95% CI)
					from 17.0 to 74.4)					
Zeru 2021[86]	Up to 30 December 2020.	14 (1999–2020)	9233 (obtained from primary studies)	Ethiopia	Adults	Community-based	Diabetes	A plasma glucose level of 7.8 mmol/L (200 mg/L) or higher	646 (estimated)	7.0 (5.0–9.0)
Zhang 2021	Inception to 28 February 2020	23 (2005–2019)	30 565	China	NR (ranged from ≥12 to 78)	Hui population	Hypertension	(SBP/DBP) ≥ 140/90	8558 (estimated)	28.0 (24.0–32.0)

Table displaying prevalence levels for insufficient physical activity (adults: less than 150 min a week; children: less than 60 min a day), diet (adults and children: Mediterranean diet style), nicotine exposure (adults and children: current use of cigarettes or inhaled nicotine), sleep (children and adults: sleep health of PSQI > 5), obesity (adults: body mass index ≥ 30 kg/m^2; children: body mass index in the 95th percentile according to their reference population), dyslipidemia (adults and children: one or more abnormal levels of any lipid profile), diabetes (adults and children: fasting blood glucose 126 mg/dL), and hypertension (adults: SBP or DBP ≥ 140/90; children: SBP and/or DPB according to the 95th percentile of their reference population), unless other prevalence outcomes stated.

NR, not reported; SBP, systolic blood pressure; DBP, diastolic blood pressure; AIS, Athens Insomnia Scale; PSQI, Pittsburgh Sleep Quality Index; OGTT, Oral Glucose Tolerance Test; BSF, Blood Sugar Fasting; BSR, Blood Sugar Random; ADA, American Diabetes Association; WHO, World Health Organization; 2hBG, 2-hour oral glucose; T2DM, type 2 diabetes mellitus; TC, total cholesterol; BP, blood pressure; FPG, fasting plasma glucose; LMIC, low and middle income countries; ACC, American College of Cardiology; AHA/NHLBI, American Heart Association/National Heart, Lung and Blood Institute; NCEP/ATP III, National Cholesterol Education Programme's Adult Treatment Panel III; IDF, International Diabetes Federation; HDL-C, High Density Lipoprotein Cholesterol; LDL-C, Low Density Lipoprotein; TG, Triglycerides; KIDMED, Mediterranean Diet Quality Index for children and teenagers; RBG, Random blood glucose; IFG, Impaired fasting glucose; CSHQ, Children's Sleep Habits Questionnaire; ICSD, International Classification of Sleep Disorders; DSM, Diagnostic and Statistical Manual of Mental Disorders; FBG, Fasting Blood Glucose; ICD, International Classification of Diseases.

studies ranged from 1681 to 103 138 833 participants.[81,88] Meta-analyses included 2 555 639 participants from 104 countries.

3.3 Quality assessment

Among the included studies, an average percentage of 60.2% of the items from the AMSTAR 2 tool was accomplished (see Supplementary material online, *Table S2*). According to AMSTAR 2 guidelines 2.5% met the criteria for high quality, 10.2% met the criteria for moderate quality, 20.3% met the criteria for low quality, and 67.0% met the criteria for being considered as critically low-quality systematic reviews.

3.4 Physical activity

Six studies assessed physical activity in the qualitative synthesis.[3,27,30,57,65,81] Overall, the prevalence of insufficient physical activity ranged from 4.0% (Australia) to 72.0% (China).[30,65] For the quantitative analysis (*Figure 2*), four studies with crude data on the number of participants and cases were used ($n = 526\,705$).[3,27,30,57] The overall pooled estimate of the prevalence of insufficient physical activity was 26.3% (95% CI 2.3%-63.4%). The subgroup of adults showed a prevalence of 7.9% (95% CI 1.5%-18.9%). Heterogeneity between studies was considerable ($I^2 = 100.0\%$).

3.5 Diet

Three studies examined the prevalence of no adherence to a healthy diet,[3,41,65] although only one examined the adherence to a Mediterranean diet.[41] Peng *et al.*[65] reported that a specific combination of fruits and vegetables, fish, fibre-rich whole grains, sodium, and sugar-sweetened beverages consumption was met by 11.3% (95% CI 10.6%-11.9%) of a sample of adults from 28 countries. Quantitative synthesis (*Figure 2*) included two studies ($n = 195\,562$),[3,41] which showed an overall prevalence of no adherence to a healthy diet of 34.1% (95% CI 5.8%-71.2%) ($I^2 = 100.0\%$).

3.6 Nicotine exposure

Eight studies assessed current cigarette use, inhaled use, or passive exposure to nicotine,[3,5,47,65,68,70,82,84] which ranged from 10.4% among the general population of Nigeria to 48.7% in a community population of China.[68,84] Three studies ($n = 345\,948$) were included in the quantitative synthesis (*Figure 2*).[68,70,82] The pooled estimate of the prevalence of nicotine exposure was 15.4% (95% CI 10.4%-21.2%) ($I^2 = 99.9\%$).

3.7 Sleep

Seven studies assessed sleep health.[29,33,53,60,72,78,85] The prevalence of non-compliance with enough sleep quality ranged from 15.1% (China) to 53.0% (Ethiopia).[29,60] When accounting for the risk of overlapping data, two studies were used for the quantitative synthesis ($n = 84\,924$) (*Figure 2*).[60,78] The pooled estimate of the prevalence of insufficient sleep quality was 38.5% (95% CI 14.0%-66.7%) ($I^2 = 100\%$).

3.8 Obesity

Sixteen studies assessed the prevalence of obesity, which ranged from 5.4% (Ethiopia) to 49.4% (China).[3,5,18,21,25,36,39,43,46,49,54,63,64,67,74,88] Seven studies ($n = 340\,240$) were included in the quantitative synthesis,[3,25,36,39,43,49,54] providing data on pooled prevalence of children obesity (13.9% [95% CI 8.8%-19.9%]), adult obesity (26.1% [95% CI 7.9%-50.1%]), and overall obesity (17.3% [95% CI 6.1%-32.6%]) (*Figure 2*). Heterogeneity between studies was considerable ($I^2 = 100.0\%$).

3.9 Dyslipidemia

Seven studies provided data on the prevalence of dyslipidemia and were included in the qualitative synthesis,[4,5,37,50,65,75,76] which ranged from 34.1% (Vietnam) to 41.6% (Iran).[37,75] The pooled estimated prevalence of dyslipidemia in the two used studies ($n = 120\,693$) for the quantitative synthesis[4,50] was 34.1% (95% CI 33.8%-34.4%) ($I^2 = 17.7\%$) (*Figure 2*).

Figure 1 Countries with available data for prevalence estimates of cardiovascular disease risk factors.

3.10 Diabetes

Seventeen studies provided data on the prevalence of high fasting blood glucose or other proxy measurement diabetes mellitus.[5,16,20,21,34,44,48,56,57,63–66,77,83,86,90] Prevalence of diabetes mellitus ranged from 4.0% in West Africa (Cameroon and Nigeria) to 28.8% (China).[57,66] The pooled estimate of the prevalence of diabetes was estimated using six studies ($n = 375\,914$).[20,34,48,57,66,90] This estimation showed a 12.0% (95% CI 7.0%-18.2%) prevalence of diabetes ($I^2 = 99.9\%$) (*Figure 2*).

3.11 Hypertension

Thirty-five studies assessed the presence of hypertension and were included in the qualitative synthesis.[5,6,17,19,22–24,26,28,31,32,35,38,40,42,45,51,52,55,58,59,61–66,69,71,73,77,79,80,87,89] Prevalence of hypertension ranged from 6.2% (Brazil) to 55.2% (older African adults).[40,51] The eleventh used studies for the quantitative synthesis[6,17,22,28,35,38,42,55,61,66,71] ($n = 933\,441$) showed a pooled prevalence of hypertension of 27.0% (95% CI 23.2%-31.0%) ($I^2 = 99.9\%$) (*Figure 2*). The subgroup of children showed a pooled prevalence of hypertension of 18.7 (95% CI 1.7%-47.7%) ($I^2 = 99.7\%$), whereas the subgroup of adults showed a pooled prevalence of hypertension of 29.4% (95% CI 23.3%-35.8%) ($I^2 = 99.9\%$) (*Figure 2*).

3.12 Publication bias

The LFK index for the Doi plots showed no asymmetry for nicotine exposure (LFK = 0.80), minor asymmetry for obesity (LFK = 1.31) and dyslipidemia (LFK = 2.00), and major asymmetry for hypertension (LFK = 2.66), sleep (LFK = 4.01), diabetes (LFK = −2.93), diet (LFK = −3.76), and physical activity (LFK = −4.57) (see Supplementary material online, *Figure S2*).

3.13 Sensitivity analyses

Leave-one-out meta-analyses identified highly influential studies for body mass index, diabetes, and hypertension (see Supplementary material online, *Figure S3*). When removing such highly influential studies, meta-analyses for the four mentioned CVH factors showed slight prevalence variations (see Supplementary material online, *Figure S4*).

4. Discussion

Overall, the three most prevalent cardiovascular risk factors worldwide in the examined period were insufficient sleep quality, dyslipidemia, and no adherence to a healthy diet. Hypertension was the most prevalent cardiovascular risk factor in subgroup analyses for both children and adults. These findings emphasize the importance of preventing high prevalence of specific cardiovascular risk factors and identify insufficient sleep quality as the most prevalent cardiovascular risk factor worldwide when accounting for the whole age range of the population. Insufficient sleep quality has been included for the first time in the AHA's CVH metrics, and the present findings indicate a need for specific strategies aiming at reducing such high prevalence worldwide.

To date, prior research examining the global prevalence of cardiovascular risk factors has not evaluated prevalence of insufficient sleep quality,[1] probably due to the fact that the focus was put on other cardiovascular risk factors and that insufficient sleep quality has only been considered recently as a CVH factor by the AHA.[2,91] Particularly, insufficient sleep quality, which has shown a strong association with cardiovascular diseases, may require a higher attention from CVH stakeholders.[92,93] Furthermore, specific strategies may also focus on reducing the prevalence of hypertension among children and adults and insufficient levels of physical activity among children.

4.1 Physical activity

Importantly, our results on the overall prevalence of physical inactivity endorse those observed by Guthold et al. since differences between studies are small (i.e. 27.5% vs. 26.3%) for a similar temporal framework (i.e. 2001–2016),[94] which gives us confidence in our estimates. In the present study, the prevalence of insufficient physical activity was higher for the mixed subgroup. Only one single study examining children was observed concerning high prevalence among this population.[3] This point may also be reinforced owing to the fact that most of the participants included in the meta-analysis for the mixed subgroup, which also shows a high prevalence, mostly comprised of children and young adults. However, we did not estimate the prevalence of physical inactivity among children due to the lack of systematic reviews providing data on this age group, but estimates calculated from

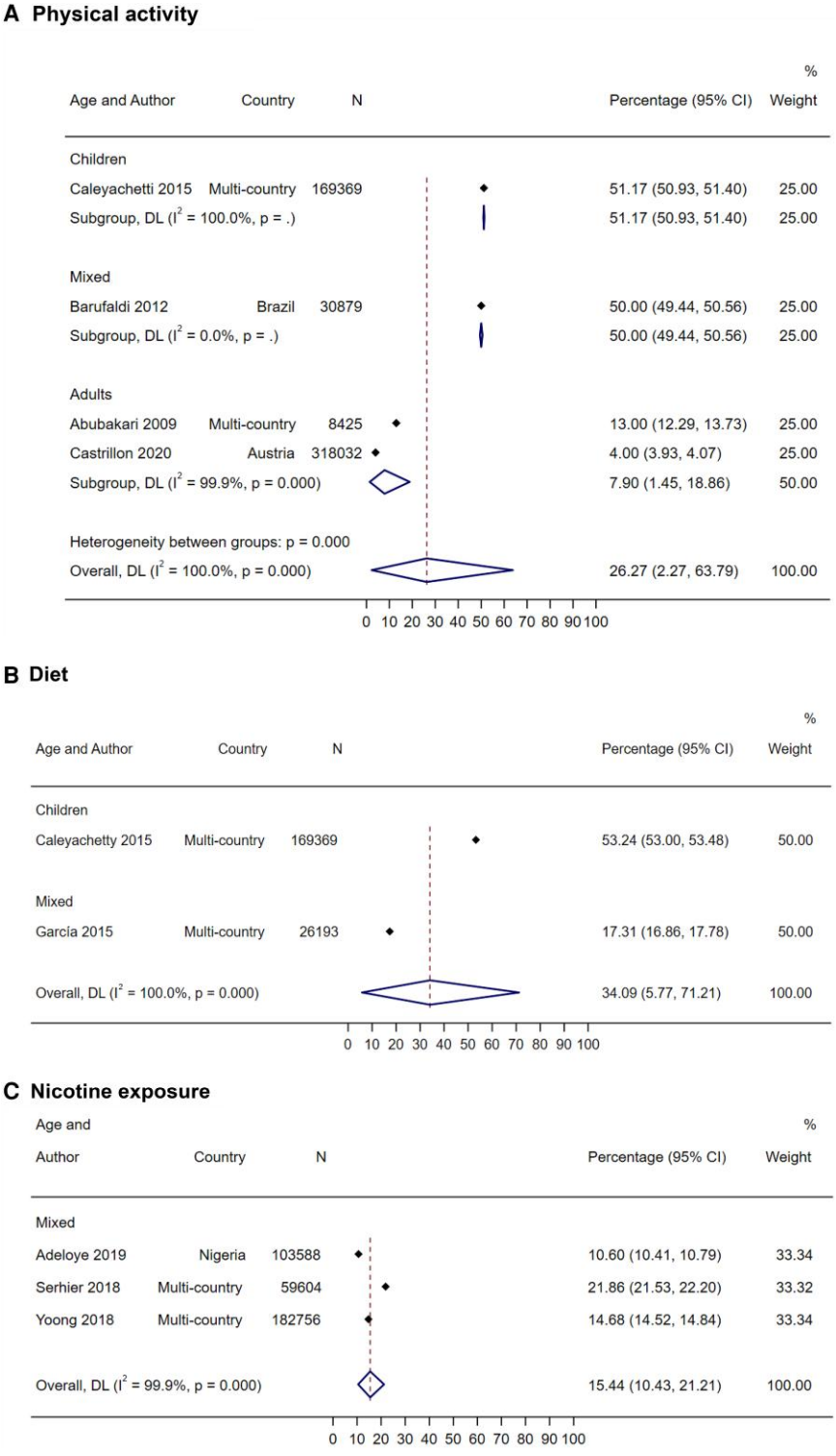


Figure 2 Estimated prevalence for CVD risk factors. *(A)* Physical activity. *(B)* Diet. *(C)* Nicotine exposure. *(D)* Sleep. *(E)* Obesity. *(F)* Dyslipidemia. *(G)* Diabetes. *(H)* Hypertension. Forest plot for prevalence (%) and 95% Confidence Interval of each CVD risk factor among worldwide population. Risk factors were the following: insufficient physical activity (adults: less than 150 min a week; children: less than 60 min a day), diet (adults and children: Mediterranean diet style), nicotine exposure (adults and children: current use of cigarettes or inhaled nicotine), sleep (children and adults: sleep health of PSQI > 5), obesity (adults: body mass index ≥30 kg/m^2; children: body mass index in the 95th percentile according to their reference population), dyslipidemia (adults and children: one or more abnormal levels of any lipid profile), diabetes (adults and children: fasting blood glucose 126 mg/dL), and hypertension (adults: SBP or DBP ≥ 140/90; children: SBP and/or DBP according to the 95th percentile of their reference population). Note: The Clopper-Pearson method was used to determine 95% CIs for prevalence from the individual studies. A Freeman-Tukey double arcsine transformation was conducted to stabilize the variances before calculating the pooled prevalence. Abbreviations: CI, Confidence Interval; DBP, Diastolic Blood Pressure; DL, DerSimonian and Laird, FBG, Fasting Blood Glucose; HDLC, High Density Lipoprotein Cholesterol; I^2, Higgins´ I^2; SBP, Systolic Blood Pressure.

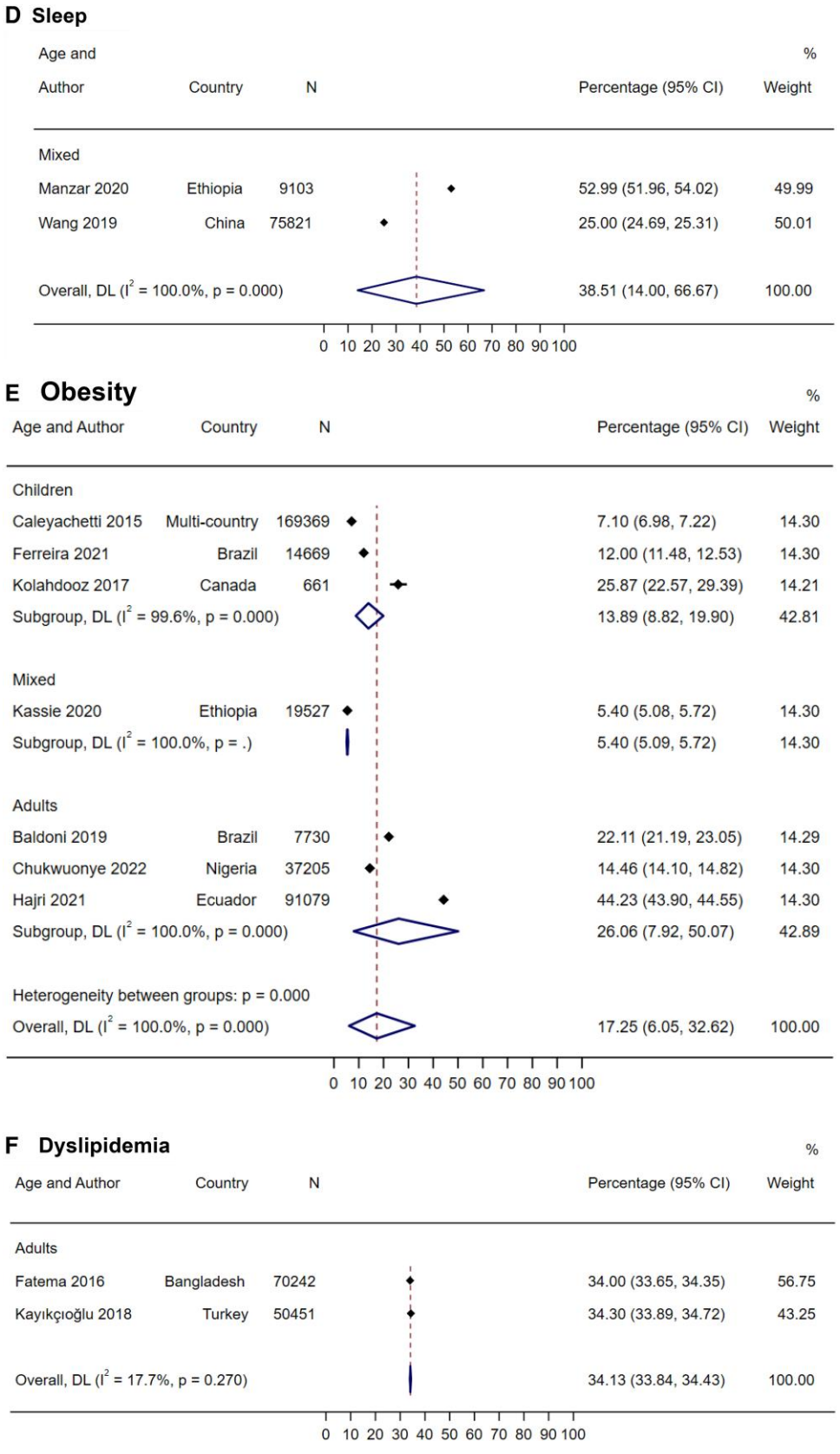


Figure 2 Continued

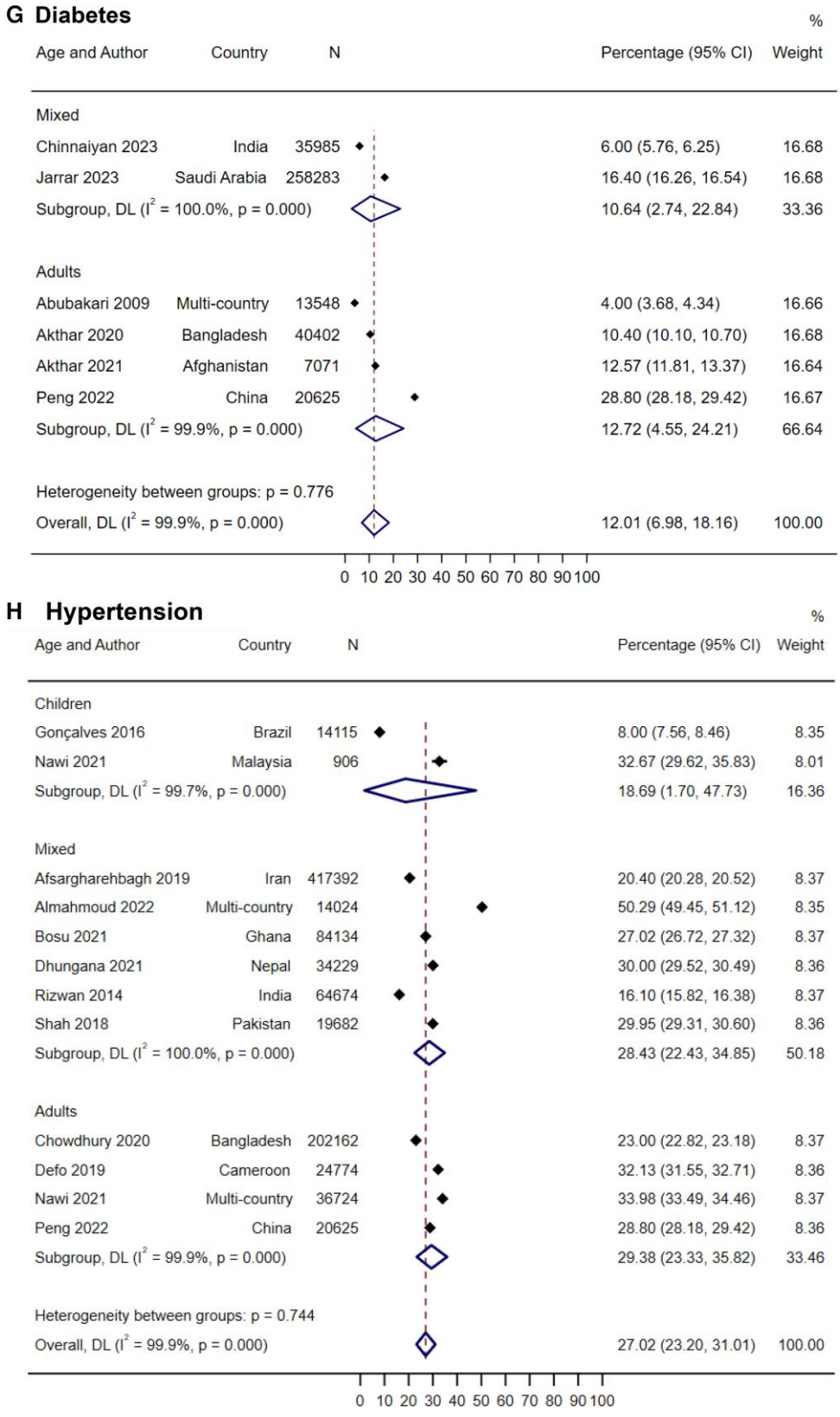


Figure 2 Continued

other studies suggested the very high prevalence of insufficient physical activity among adolescents aged 11–17 years.[95] The recommended guidelines for physical activity among children and adolescents are more demanding (i.e. 60 min/wk.), which makes it more difficult to meet the goals for this subgroup, particularly among adolescents who tend to reduce their levels of physical activity.[96] However, the need for engaging in higher levels of physical activity during childhood is supported since it has been observed to reduce the odds of hypertension and type 2 diabetes in later adulthood.[97] Particularly, among obese children and teenagers, the benefits of physical activity over CVH may be driven by mitigating other cardiovascular risk factors.[98]

4.2 *Diet*

The prevalence of no adherence to a healthy diet was high worldwide. Comparisons with other studies are difficult due to the different ways to measure a healthy diet. However, there are repeating patterns such as high-rich fibre consumption through fresh vegetables and fruits, legumes, nuts, whole grain, and seed-based food that feature Dietary Approaches to Stop Hypertension (DASH) or Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) diets.[99] The variability for the prevalence of no adherence to a healthy diet estimated in our study is high. The latter is not a surprising result since prior research has also observed such high variability for low fruit and vegetable consumption (i.e. five servings of fruits and/or vegetables daily) mainly due to the different dietary patterns regarding countries, sex, age, and income.[100] However, owing to the well-spread sample used in this study, which comprised 70 countries, our estimations may provide reliable information on the status of this cardiovascular risk factor for children and young adults together (i.e. 2–25 years), although the prevalence of this risk factor may be substantially higher for particularly older individuals from low-income countries. This issue has also been reported in prior research.[100]

4.3 Nicotine exposure

We estimated low prevalence levels of Nicotine exposure worldwide, which agrees with the fact that smoking levels have decreased over the last decades.[101,102] Prior research has examined smoking levels stratified by sex solely, and this hampers straightforward comparisons, but our estimations might not be so far from those observed previously.[101] Our estimations have also the advantage of accounting for nicotine delivery systems and second-hand smoking, which have been considered harmful for CVH along with cigarette smoking.[2] This provides a wider and more accurate perspective of the issue. Although there have been consistent reductions in smoking prevalence worldwide,[102] there is less knowledge on the progression of second-hand smoking and, particularly, the impact of the nicotine delivery systems, which have shown a substantial prevalence among adolescents.[103,104] The importance of second-hand smoking and nicotine delivery systems in the prevalence of nicotine exposure may be attenuated in our study owing to the contribution of older individuals included in the primary studies in this analysis.

4.4 Sleep

We identified insufficient sleep quality as the most prevalent cardiovascular risk factor worldwide. Our estimations were mostly based on the PSQI, a tool that assesses several components of sleep quality and provides an overall score. However, prior research has usually focused on the prevalence of several sleep patterns from specific populations. For instance, a study by Gordon *et al.*[105] observed a prevalence of 30% for less than the recommended sleep hours (i.e. < 7 hours/day), 13% for frequent insomnia, 18% for frequent insomnia/poor quality sleep, and 8% potential sleep apnoea symptoms among community-dwelling older adults. Because these sleep problems can be experienced combined among older adults, and less than recommended sleep time is highly prevalent among children,[105,106] estimations of a high overall prevalence of insufficient sleep quality, as observed in our study, are plausible. Even when measured by using actigraphy and with a very low demanding sleep time reference (i.e. < 7 h/day), the prevalence of insufficient sleep time is substantial among children aged 6 to 12 years.[107]

4.5 Obesity

The prevalence of obesity was not among the highest prevalence of cardiovascular risk factors observed in the present study. However, there is still a relevant prevalence of obesity, particularly among adults. According to a study from the Global Burden of Disease on Non-Communicable Risk Factors group, the increase of body mass index has recently plateaued in many geographical areas such as northwestern Europe and the high-income English-speaking and Asia-Pacific regions over the last decades,[108] which may partially explain that we did not observe higher prevalence obesity levels. By contrast, these flattened body mass index trends have not yet represented an overall worldwide reduction in trends of obesity among children and adolescents over the last decades, which have even increased and may represent future increases in the prevalence of obesity also among adults. This trend can already be observed in a densely populated country such as China.[108,109] A better understanding of the critical geographical differences in obesity prevalence may contribute to particular causes of obesity and promising public health strategies for the future.

4.6 Dyslipidemia

The prevalence of dyslipidemia was among the highest of the cardiovascular risk factors examined in our study. However, it has to be noticed that we used an aged sample population in our estimations; thus, the prevalence of dyslipidemia among younger people may be considerably lower since usually increases with age.[110] A similar or even higher prevalence of dyslipidemia has also been observed among Turkish and Chinese middle- to older-aged adults.[111,112] Variances may be driven by the different proxies considered to define dyslipidemia as prior research has considered any abnormality in total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, or triglycerides, which can be presented either solely or combined.[112] Prevalence of dyslipidemia may be reduced with adequate cardiovascular risk management as observed in older adult men from the US.[113]

4.7 Diabetes

Our overall estimate of global diabetes prevalence was slightly higher than previously observed in a longer period (i.e. 1990–2018).[114] Such differences may be due to different geographical study populations, since our study focuses on regions such as Africa or the Middle East where prevalence levels are higher than in other regions, and lacks data from regions with lower prevalence of diabetes such as Northern- or Western-Europe.[115] Even though the overall prevalence of diabetes is not among the highest cardiovascular risk factors worldwide, future projections for specific geographical areas of South America, Asia, Middle-East, or Africa are concerning,[115] and monitorization of these prevalence levels to know the impact of public health policies is warranted.

4.8 Hypertension

Our overall prevalence of hypertension worldwide among adults was slightly lower than estimated in another study using data from 2010 (29.4% vs. 31.1%).[116] However, estimations for children and adolescents differ more depending on the study, although generally, we found a higher prevalence of hypertension among children than in other studies comprising either regional or overall study samples.[73,117] This difference may be because our study sample focused on countries with a higher prevalence of hypertension among children. Yet, there is also the possibility that our estimates also reflect the growing trend in global hypertension observed among children over the last decades.[73] Such concerning growing trends can be observed among adults in almost any single geographical region except for Central and Eastern Europe, which along with the fact that there is still an improvement in control and treatment of this condition among the population,[118] makes this cardiovascular risk factor one of the main targets to address through efficient strategies.

4.9 Strengths and limitations

This systematic review extracted data from 79 studies and retrieved data from 2 555 639 participants from 104 countries for meta-analyses on the prevalence of cardiovascular risk factors. Moreover, strict adherence to reporting guidelines (PRIOR) and a thorough search of databases and additional sources were used to identify meta-analyses on cardiovascular risk factors. Our analyses accounted for the potential risk of overlapping data and were strict when including studies with data comprising the study period in the quantitative analyses. However, the results of the present study should be interpreted in the light of the following constraints: (i) Given that we used few studies for the quantitative analyses of three cardiovascular factors (i.e. diet, sleep, and dyslipidemia), these estimations of prevalence should be treated with caution. (ii) Owing to the combination of data from a wide range of geographical regions as well as different age and sex categories, the level of heterogeneity found in most of our estimations of the prevalence of the examined cardiovascular risk factors was high. However, this issue is common in studies examining the worldwide prevalence of cardiovascular risk factors since prevalence can widely vary among countries and populations with specific features.[102,118] (iii) The generalizability of the results is limited to the studies included in our study, in which high-income countries were underrepresented due to the lack of systematic reviews with meta-analysis on prevalence in these geographical regions. However, these estimates can complement those from the existing literature on the topic which usually integrates less data on low-income countries.[119] (iv) Since we included studies based on self-reported data on physical activity, diet, nicotine exposure, and sleep, there is a certain risk of recall bias that might have any influence on the results. Also, due to the lack of homogeneity in measuring specific cardiovascular risk factors such as diabetes or diet, a risk of misclassification bias exists. (v) The low quality of several studies may influence the prevalence estimates obtained in the present overview. (vi) Due to the low number of studies included in the meta-analyses, subgroup analyses concerning sex or geographical regions were not possible. However, since an important number of low-to middle-income countries from Asia, Africa, and South America have been considered in our estimates, it is likely that the present study reflects more accurately the global prevalence of cardiovascular risk factors than other studies with more geographical-restricted data use. In fact, it is particularly concerning the high prevalence of physical inactivity in Brazil, the high prevalence of insufficient sleep quality in Ethiopia, the high prevalence of obesity among adults in Ecuador, and the high prevalence of hypertension among children in Malaysia, which deserves further investigation.

5. Conclusions

Identifying the more prevalent cardiovascular risk factors based on the updated LE8 is useful for prioritizing policy strategies to improve CVH worldwide. The present findings highlight the need for prevention strategies aimed particularly at reducing insufficient sleep quality, the new cardiovascular risk factor added by AHA to the CVH metrics, dyslipidemia, and lack of adherence to a healthy diet. Moreover, the high prevalence of hypertension among children and adults is also concerning and should be adequately addressed through global policies. Additionally, there is a need for information on the prevalence of any of the 8 examined cardiovascular risk factors in many countries from different geographical areas. In particular, data from Eastern Europe, Caribbean countries, Central America, Central South America, Central Africa, and Central Asia are lacking.

Supplementary material

Supplementary material is available at *Cardiovascular Research* online.

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Data availability

Data concerning the present study is available upon request.

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