Meta-Analysis

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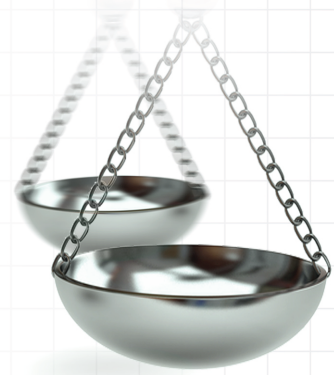

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Systematic literature review and meta-analysis of cardiovascular risk factor management in selected Asian countries

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Aim: There is a need to understand the management status of hypertension, dyslipidemia/hypercholesterolemia, and diabetes mellitus in the Asia–Pacific region (APAC). **Methods:** We conducted a systematic literature review and meta-analysis to summarize the awareness, treatment, and/or control rates of these risk factors in adults across 11 APAC countries/regions. **Results:** We included 138 studies. Individuals with dyslipidemia had the lowest pooled rates compared with those with other risk factors. Levels of awareness with diabetes mellitus, hypertension, and hypercholesterolemia were comparable. Individuals with hypercholesterolemia had a statistically lower pooled treatment rate but a higher pooled control rate than those with hypertension. **Conclusion:** The management of hypertension, dyslipidemia, and diabetes mellitus was suboptimal in these 11 countries/regions.

Tweetable abstract: Cardiovascular risk factor management was suboptimal in several Asia–Pacific countries/regions. Compared with hypertension and diabetes mellitus, dyslipidemia was the most neglected risk factor. #cvd #prevention #lipids #asia

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Keywords: awareness • cardiovascular disease • control • diabetes mellitus • dyslipidemia • hypertension • treatment

Cardiovascular disease (CVD) is the leading cause of death globally [1], and in 2019, 58% of the deaths occurred in Asia [2]. The WHO established a global action plan by the year 2025, aiming to reduce by 25% the number of premature deaths from non-communicable diseases, including CVD [3]. Recommended targets to reduce cardiovascular risk factors include a 10% reduction in physical inactivity, a 30% reduction in tobacco use, a 25% reduction in hypertension, and no increase in diabetes mellitus and obesity [4]. For most countries/regions, resources are generally limited, resulting in unequal access to healthcare and increased morbidity and mortality [4]. To prioritize efforts and reach WHO targets, the status of cardiovascular risk factor management must be understood. Data on cardiovascular risk factor management over time have been reported for Canada and the US [5], but little is known in the Asia-Pacific (APAC) region. Therefore, this systematic literature review (SLR) and meta-analysis (MA) aimed to summarize awareness, treatment, and control rates of hypertension, dyslipidemia, and diabetes mellitus as a proxy of cardiovascular risk factor management in 11 APAC countries/regions.

Methods

Search strategy & selection criteria

We searched MEDLINE, EMBASE and IMSEAR electronic databases for articles indexed from 1 January 2004, until 30 June 2020. The strategy search used terms is listed in Supplementary Table 1. Relevant articles from reference lists from the included articles, as well as from systematic review and meta-analysis, were also assessed for eligibility. The reviews were performed independently and in a blinded fashion by two authors (RBG and APB) using the Rayyan® platform [6]. Any discrepancies were resolved by consensus.

Table 1. Definitions of hypertension, dyslipidemia, and diabetes mellitus by the authors of included studies.

Risk Factors	Definitions used by the author of the included studies
Hypertension	• SBP ≥140 mmHg and DBP ≥90 mmHg • SBP 130 mmHg and DBP ≥80 mmHg • Self-reported pharmacological treatment for hypertension within the 2 weeks prior to the interview
Diabetes mellitus	• Fasting plasma glucose ≥126 mg/dl (7.0 mmol/l) • HbA1c ≥6.5%, 2-hour plasma glucose level ≥200 mg/dl • A self-report of a doctor diagnosis of diabetes mellitus
Dyslipidemia	• TC≥6.22 mmol/l (240 mg/dl), and/or • TG≥2.26 mmol/l (200 mg/dl), and/or LDL≥4.14 mmol/l (160 mg/dl), and/or • HDL <1.04 mmol/l (40 mg/dl), and/ or • Use of lipid lowering medications in the past two weeks
Hypercholesterolemia – LDL-c	• LDL-cholesterol greater than 190 mg/dl, greater than 160 mg/dl with one major risk factor, or greater than 130 mg/dl with two cardiovascular risk factors

Study eligibility was based on the PICOS (population, intervention, comparator, outcomes, study type) criteria listed in Supplementary Table 2. Eligible studies included those: with the target population being the general adult population (≥18 years old) from Australia, China, Hong Kong Special Administrative Region, India, Japan, Malaysia, Philippines, Singapore, South Korea/Republic of Korea, Taiwan, or Thailand; reporting the outcomes of interest (awareness, treatment and control rates) for the target risk factors (hypertension, dyslipidemia and diabetes mellitus); These outcomes were selected as a proxy of cardiovascular risk factor management based on a similar SLR conducted by Alaboursi *et al.* where a classification system of performance ratings was proposed [5]. Using population- or community-based observational designs (including cohort, cross-sectional and surveys) or quasi-experimental designs (including community-based interventional studies); written in English, German, French, Spanish or Portuguese languages, which were chosen based on the language capacity of the research teams. However, a publication suggested exclusion of languages other than English in SLR would not significantly affect the results of the meta-analyses [7]; and, available in full-text. It is important to notice that the general adult population may consist of a proportion of individuals with a history of CVD. When two or more studies used the same sampling source during similar periods that may lead to potential duplicated or overlapped samples, the article with the largest sample size and most recent data was included. For studies presenting data by different periods of time (e.g., 2007 vs 2013), only the most recent data was reported and included in the analysis.

Studies or reports with any of the following conditions were excluded: book chapters, letters, conference abstracts, and government reports; studies that did not provide sufficient information to obtain or calculate the awareness, treatment and/or control rate(s); studies with the primary interest in specific populations with out-of-scope conditions, such as chronic kidney disease, mental illness, rheumatoid arthritis, cancer and CVD other than hypertension (e.g., acute coronary syndrome [ACS] including non-ST and ST elevation myocardial infarction non-ST segment elevation myocardial infarction [STEMI and NSTEMI, respectively], and unstable angina [UA]), transient ischemic attack (TIA), ischemic stroke or subarachnoid hemorrhage; studies that sampled only a particular segment of the population (e.g., individuals from certain race/ethnicities, veterans, indigenous groups, immigrant groups, monks, healthcare professionals or specific segments of the population such as only teachers, only large industry workers); studies with individuals aged ≥15 years old but data cannot be stratified to obtain information for individuals aged ≥18 years old. These exclusions were meant to focus our report on samples that represent the general adult population.

Data extraction

We extracted the following variables, defined *a priori*: metadata [authorship, year of publication, country/region, living areas (urban/rural/mixed), and type of study design]; demographics (sample size and age range); CVD risk factor(s); numbers and/or proportions of individuals related to awareness, treatment and/or control rates for each risk factor.

Table 1 shows examples of different definitions used by authors to characterize the risk factors of the included studies. Notice that various definitions or criteria (e.g., treatments considered, criteria or local guidelines to define how the risk factor was controlled) may be used across studies studies. This SLR used whatever definitions or criteria used by researchers of included studies. Table 2 lists definitions used to obtain information about awareness, treatment and control rates. Notice that awareness was self-reported by individuals, and the denominator of the

Table 2. Definitions of awareness, treatment, and control rate by the authors of included studies.

Outcome	Definitions
Awareness rate	Numerator: the number of individuals who self-reported either having been diagnosed with the risk factor by a clinician/healthcare professional or who self-reported taking medication to treat the risk factor of interest.[†,§] Denominator: the number of individuals with the risk factor of interest.[‡]
Treatment rate	Numerator: the number of individuals receiving prescribed medication(s) for the risk factor (only pharmacological treatment, including allopathic or any alternative medicine medications).[§] Denominator: the number of individuals with the risk factor of interest.[‡]
Control rate	Control rate among individuals with the risk factor of interest: Numerator: the number of individuals with the risk factor whose BP or lipid panel or A1C measures were under control.[§] Denominator: the number of individuals with or without medications for the risk factor of interest.[‡] Control rate among individuals being treated for the risk of interest: Numerator: the number of individuals with the risk factor who are being or have been treated with medications and had their BP or lipid panel or A1C measures under control.[§] Denominator: the number of individuals treated with medications for the risk factor of interest.[‡]

[†] Awareness was self-reported by individuals or patients in the included studies.
[‡] This number was estimated or observed by researchers rather than self-reported by individuals or patients in included studies.
[§] various definitions or criteria may be used across included studies. This systematic literature review used whatever definitions or criteria used by researchers of included studies.
BP: Blood pressure; A1C: Glycosylated hemoglobin test.

awareness rate (i.e., the number of individuals with the risk factor of interest) was estimated or observed by researchers of each included study. With the purpose to demonstrate a comprehensive scenario, we presented the control rate separately based on the prevalence rate and the treatment rate.

Data analysis

We performed quantitative data syntheses and reported results per the PRISMA Statement [8]. All analyses were performed using the statistical packages for meta-analysis of R software 4.1.1 for macOS. The analysis was performed by each study outcome within each risk factor separately. We reported stratification analyses by country and urban/rural area in this paper but not by other variable (e.g., by age group, gender, study type, etc.). Our rationale to report the pooled estimates by country/region or urban/rural area because such information is relatively important to decisions, implementation or changes in clinical practice to improve CV risk factor management at the country/region level. Other analyses were either not feasible (e.g., inadequate subgroups for each study outcome and risk factor within each country) or limited space in this paper does not accommodate all results to be presented. For the modeling of binominal data, we adopted an approximate likelihood approach by using the Freeman-Tukey double arcsine raw data, instead of weighted or standardized estimates, from articles that were used to compute pooled estimates. Transformation for computation of the pooled estimates and performing the back-transformation for stabilizing variances [9]. Thus, all the studies are retained independently of extreme proportions (0 and 100%). Furthermore, admissible confidence intervals (CIs) for each study are provided, in addition to the pooled rates. We adopted the random-effects model using the method of DerSimonian and Laird, with the estimate of heterogeneity being taken from the inverse-variance fixed-effect model [10]. We chose this model because we expected high heterogeneity among the studies.

Heterogeneity was evaluated using the I^2 and the χ^2 test ($p < 0.05$ for heterogeneity), which assess the overlap between the CI of the proportion of each group. Subgroup analyses by market and were performed by comparing heterogeneity between groups, as defined by χ^2 and $p < 0.05$.

Publication bias was assessed utilizing the Egger's test [11] and the funnel plot, which displays confidence interval boundaries to assist publication bias through the visualization of the distribution of the studies in the limits of the funnel (e.g., whether studies are distributed symmetrically and fall within the funnel margins).

The quality of the studies included in this SLR was assessed with the Newcastle Ottawa Scale (NOS) [12]. The NOS score for observational studies has a maximum of 10 points, and a study is considered of very good quality if scoring 9–10 points, good quality if 7–8 points, satisfactory quality if 5–6 points, and unsatisfactory quality if 0–4 points [12].

Results

This SLR yielded 4134 studies and 85 duplicates were removed, resulting in 4,049 studies to be evaluated. In a preliminary eligibility evaluation, we excluded 71 unavailable records not presenting results in the abstract. In a more detailed subsequent evaluation, we excluded 3839 articles for the following reasons: ineligible population

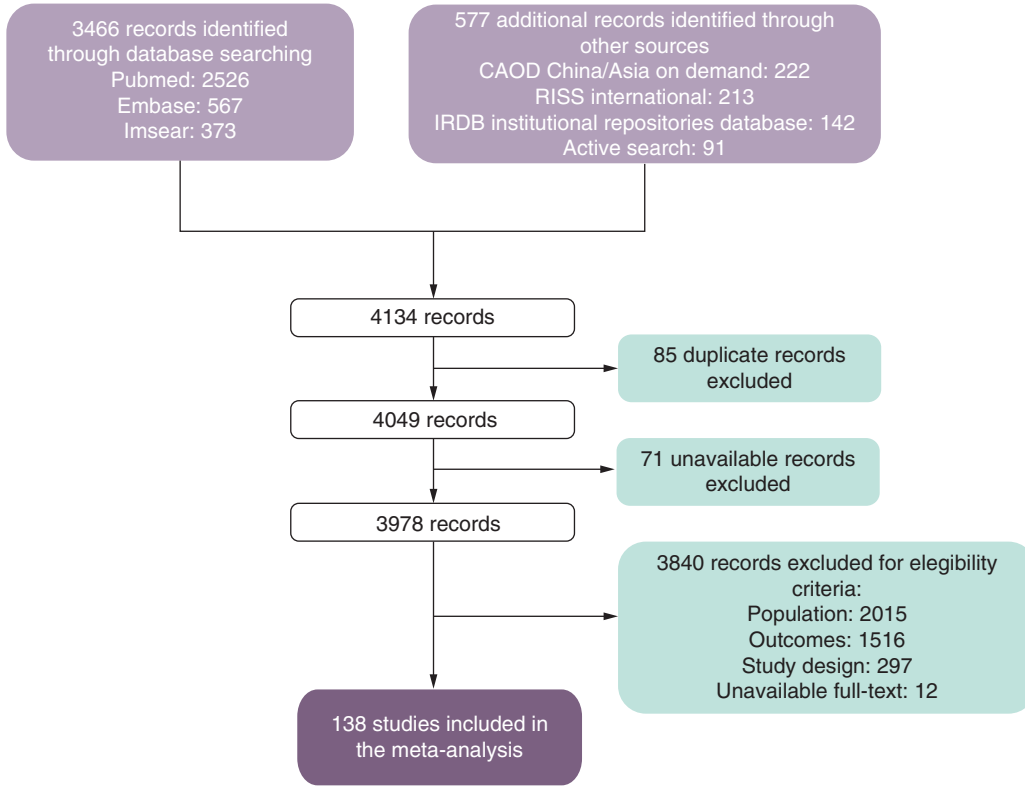

Figure 1. PRISMA flow diagram of the selection of the studies.

(n = 2015), inappropriate outcomes (n = 1515), inappropriate study design (n = 297) and unavailable full-text (n = 12). We included 138 studies in the final quantitative analysis. Five eligible studies included data related to two risk factors of interest [13–17]. In those cases, these studies were counted once for one risk factor and once for the other risk factor as showed with specific labels in the graphics and tables. Figure 1 shows the detailed flow of the study selection.

This SLR included a total of 6,312,710 study subjects across 138 studies, among which 116 studies included 6,132,901 subjects with hypertension, 19 studies included 58,789 subjects with diabetes mellitus, and 14 studies included 121,020 subjects with dyslipidemia (among which 6 studies specified 78,462 subjects with hypercholesterolemia). The numbers of included studies by country/region were: Australia (n = 6), China (n = 86), India (n = 23), Japan (n = 2), Malaysia (n = 7), Philippines (n = 1), Singapore (n = 2), South Korea (n = 4), Taiwan (n = 2), Thailand (n = 5) and Hong Kong (n = 0). Of 138 studies, 75 studies were conducted based on populations in mixed areas (urban and rural), 28 studies in rural areas, 21 studies in urban areas, and 24 studies did not report the type of area (Table 3).

Overall pooled awareness, treatment & control rates for each risk factor

Table 4 summarizes pooled awareness, treatment and control rates and 95% CIs for each risk factor. Among individuals with the risk factor of interest, the pooled awareness rate was lower for dyslipidemia (24%, 95% CI: 16–33%) than for diabetes mellitus (46%, 95% CI: 38–55%) or for hypertension (47%, 95% CI: 45–49%). The pooled awareness rate for hypercholesterolemia was numerically high (51%, 95% CI: 26–76%), but comparisons with other risk factor was inconclusive due to a wide range of CI. The pooled treatment rate in individuals with the risk factor of interest was the lowest for dyslipidemia (14%, 95% CI: 9–20%), followed by those for hypercholesterolemia (31%, 95% CI: 29–33%), for diabetes mellitus (37%, 95% CI: 31–43%) or for hypertension (40%, 95% CI: 36–44%). Interestingly, the pooled control rate was the highest among individuals with hypercholesterolemia (35%, 95% CI: 29–33%) than those with dyslipidemia (5%, 95% CI: 1–12%), those with diabetes mellitus (12%, 95% CI: 3–26%), or those with hypertension (13%, 95% CI: 11–16%). Based on population-/community-based studies showing data for those being treated with medications for the risk factor of

Table 3. Summary of included studies.

Study, year	Country	Area	Study design	Sample size, n	Age, years	Risk factor	Awareness rate	Treatment rate	Control rate†	Control rate‡	Ref.
Abdul-Razak *et al.*, 2016	Malaysia	Mixed	Cohort	5409	≥30	Hypertension	52.4	37.4	30.7	15.9	[36]
Aekplakorn *et al.*, 2012	Thailand	Mixed	Cross-sectional	6401	≥40	Hypertension	58.4	50.4		25.2	[37]
Appleton *et al.*, 2013	Australia	Did not report	Cross-sectional	781	≥18	Hypertension		59.2	35.7		[38]
Banerjee *et al.*, 2016	India	Urban	Cross-sectional	4304	≥20	Hypertension	53.0	38.0	25.8	11.6	[39]
Bhardwaj *et al.*, 2010	India	Rural	Cross-sectional	392	≥18	Hypertension	22.0			20.2	[40]
Bunnag *et al.*, 2006	Thailand	Did not report	Cross-sectional	6965	≥18	Hypertension		84.4	13.9		[41]
Businge *et al.*, 2017	India	Rural	Cross-sectional	277	≥50	Hypertension	42.6	55.1	27.7	26.7	[42]
Cai *et al.*, 2012b	China	Mixed	Cross-sectional	2040	18–79	Hypertension	42.5	84.3	33.0		[43]
Campbell *et al.*, 2018	Australia	Did not report	Cross-sectional	3847	>60	Hypertension		99.0	60.2		[44]
Castillo *et al.*, 2019	Philippines	Did not report	Cross-sectional	91994	>18	Hypertension		65.6	58.4		[45]
Chaturvedi *et al.*, 2007 (study 1)	India	Urban	Cross-sectional	334	20–59	Hypertension	53.3	42.8		10.5	[46]
Chaturvedi *et al.*, 2007 (study 2)	India	Urban	Cross-sectional	705	≥60	Hypertension	54.0	43.4		8.5	[46]
Chen *et al.*, 2016	China	Rural	Cross-sectional	5066	≥35	Hypertension	42.5	30.6	20.0		[47]
Chen *et al.*, 2018	China	Mixed	Cross-sectional	2347	18–98	Hypertension	41.8	78.8	31.5		[48]
Chen *et al.*, 2020	China	Did not report	Cross-sectional	85835	≥18	Hypertension	62.3	57.3	62.6	35.9	[49]
Chua *et al.*, 2005 (BMES I)	Australia	Urban	Cross-sectional	1645	>49	Hypertension	79.8	71.1	56.3		[50]
Chua *et al.*, 2005 (BMES II)	Australia	Urban	Cross-sectional	1825	>49	Hypertension	73.0	67.3	46.5		[50]
Dong *et al.*, 2007	China	Rural	Cross-sectional	10854	35–85	Hypertension	27.0	19.8		9.0	[51]
Dong *et al.*, 2013	China	Rural	Cross-sectional	1100	18–85	Hypertension	37.0	31.2	18.1	5.6	[52]
Fan *et al.*, 2014	China	Mixed	Cross-sectional	4531	≥25	Hypertension	46.0	35.7	29.1	10.4	[53]
Fan *et al.*, 2020 (130/80 mm Hg hypertension threshold)	China	Did not report	Cross-sectional	866	21–94	Hypertension		15.4		3.2	[54]
Fan *et al.*, 2020 (140/90 mm Hg hypertension threshold)	China	Did not report	Cross-sectional	515	21–94	Hypertension		25.8		9.7	[54]
Feng *et al.*, 2014	China	Mixed	Cross-sectional	5295	≥45	Hypertension	57.4	49.0		20.2	[55]
Gao *et al.*, 2013	China	Mixed	Cross-sectional	13196	≥20	Hypertension	45.0	36.2		11.0	[56]
Goswami *et al.*, 2016	India	Urban	Cross-sectional	477	≥60	Hypertension		41.2	32.9		[13]
Gu *et al.*, 2014	China	Urban	Cross-sectional	3328	≥65	Hypertension			36.1		[57]
Gupta *et al.*, 2017	India	Mixed	Cross-sectional	9798	≥35	Hypertension	40.4	31.9		12.9	[58]
Gupta *et al.*, 2020	India	Rural	Cross-sectional	194	≥60	Hypertension	58.8				[14]
Hazarika *et al.*, 2004	India	Rural	Cross-sectional	1058	≥35	Hypertension	21.6	21.4	18.1		[59]
Hird *et al.*, 2019	Australia	Mixed	Cohort	4113199	20–69	Hypertension			5.6		[60]

†Control rate based on treatment rate.
‡Control rate based on the sample diagnosed.

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Table 3. Summary of included studies (cont.).

Study, year	Country	Area	Study design	Sample size, n	Age, years	Risk factor	Awareness rate	Treatment rate	Control rate†	Control rate‡	Ref.
Howteerakul *et al.*, 2006	Thailand	Rural	Cross-sectional	94	≥35	Hypertension	64.9				[61]
Hu *et al.*, 2016	China	Mixed	Cross-sectional	1754	≥18	Hypertension	63.7	47.3	37.6	17.8	[62]
Hu *et al.*, 2017a	China	Mixed	Cross-sectional	4411	25–97	Hypertension	65.1	27.2		12.7	[63]
Huang *et al.*, 2017	China	Mixed	Cross-sectional	371	≥20	Hypertension	44.2	38.0	27.7	10.5	[64]
Huang *et al.*, 2019	China	Urban	Cross-sectional	4418	35–79	Hypertension	47.9	40.1	25.6	10.3	[65]
Jiang *et al.*, 2014	China	Mixed	Quasi-experimental community trial	5029	≥50	Hypertension	70.0	62.1	44.4	29.6	[66]
Karmakar *et al.*, 2018	India	Rural	Cross-sectional	170	≥20	Hypertension	48.2	47.1	18.7	8.8	[67]
Kaur *et al.*, 2011	India	Rural	Cross-sectional	2247	25–64	Hypertension	25.1	20.3	32.6	6.6	[68]
Kaur *et al.*, 2016	India	Rural	Cohort	1284	25–64	Hypertension		19.9	36.3	45.3	[69]
Kawazoe *et al.*, 2018	China	Rural	Cross-sectional	1009	50–69	Hypertension		22.5	8.4		[70]
Ke *et al.*, 2014	China	Urban	Cross-sectional	478	≥18	Hypertension	67.0	59.0	49.0	30.1	[71]
Kiau *et al.*, 2013	Malaysia	Mixed	Cross-sectional	3651	≥60	Hypertension	49.3	42.4	22.6		[72]
Kim *et al.*, 2020b	South Korea	Did not report	Cross-sectional	780	19–44	Hypertension		16.4	10.6		[25]
Lee *et al.*, 2010	South Korea	Rural	Cohort	3475	≥60	Hypertension	60.1			16.1	[73]
Lewington *et al.*, 2016	China	Mixed	Cross-sectional	152568	≥35	Hypertension		46.4	29.6	4.2	[74]
Li *et al.*, 2010	China	Rural	Cross-sectional	7164	≥25	Hypertension	26.2	22.2	17.7	3.9	[75]
Li *et al.*, 2015	China	Rural	Cross-sectional	5917	≥35	Hypertension	43.5	31.6		6.0	[76]
Li *et al.*, 2016	China	Mixed	Cross-sectional	18915	≥18	Hypertension	41.6	34.4		8.2	[62]
Li *et al.*, 2017	China	Did not report	Cross-sectional	295	18–70	Hypertension	48.8	25.1	43.2	17.6	[77]
Li *et al.*, 2020	China	Mixed	Cross-sectional	4332	≥45	Hypertension	39.4				[78]
Li *et al.*, 2019a	China	Mixed	Cross-sectional	6669	≥18	Hypertension	23.8	18.6	9.6	2.3	[79]
Li *et al.*, 2019c	China	Mixed	Longitudinal study	4594	≥45	Hypertension	53.7	41.6			[80]
Li *et al.*, 2020	China	Mixed	Retrospective pre-post self-controlled	7332	≥35	Hypertension			41.4		[81]
Liang *et al.*, 2020	China	Mixed	Cohort	3656	≥35	Hypertension		70.7		64.1	[82]
Liao *et al.*, 2016	China	Mixed	Cohort	2619	≥35	Hypertension	32.2				[83]
Lim *et al.*, 2004	Malaysia	Mixed	Cross-sectional	7225	≥30	Hypertension	33.0	23.0	26.0	6.0	[84]
Lim *et al.*, 2018	South Korea	Did not report	Longitudinal study	117264	≥65	Hypertension			72.5		[85]
Lin *et al.*, 2013	Taiwan	Urban	Cross-sectional	2145	20–49	Hypertension				63.0	[86]
Liu *et al.*, 2017	China	Mixed	Cross-sectional	3518	≥18	Hypertension	44.1	36.6	23.3	8.4	[87]
Liu *et al.*, 2018	China	Rural	Cross-sectional	9872	18–74	Hypertension	67.4	54.6		26.1	[88]
Liu *et al.*, 2019	China	Rural	Cross-sectional	5107	≥40	Hypertension	16.6	4.8	23.2		[89]
Lu *et al.*, 2017	China	Mixed	Cross-sectional	777637	35–75	Hypertension	44.7	30.1		7.2	[90]
Lu *et al.*, 2018	China	Did not report	Longitudinal study	4884	45–75	Hypertension	56.1	46.8	20.3		[16]

†Control rate based on treatment rate.
‡Control rate based on the sample diagnosed.

Table 3. Summary of included studies (cont.).

Study, year	Country	Area	Study design	Sample size, n	Age, years	Risk factor	Awareness rate	Treatment rate	Control rate†	Control rate‡	Ref.
Lv *et al.*, 2018	China	Mixed	Cross-sectional	4632	18–59	Hypertension	48.1	39.6	22.9		[91]
Ma *et al.*, 2015	China	Mixed	Longitudinal study	1275	≥18	Hypertension	57.6	56.2	21.5		[92]
Majid *et al.*, 2018	Malaysia	Mixed	Cross-sectional	7038	≥18	Hypertension	37.5	31.1	37.4		[93]
Malhotra *et al.*, 2010	Singapore	Did not report	Cross-sectional	3419	≥60	Hypertension	69.2	68.0	35.5		[23]
Meng *et al.*, 2011	China	Urban	Cross-sectional	7237	18–74	Hypertension	42.9	28.2		3.6	[94]
Mi *et al.*, 2015	China	Rural	Cross-sectional	1035	18–77	Hypertension	53.5				[95]
Mohan *et al.*, 2007	India	Urban	Cross-sectional	469	≥20	Hypertension	32.8			10.7	[96]
Muntner *et al.*, 2004	China	Mixed	Cross-sectional	4066	≥35	Hypertension	47.0	61.5	29.1	8.6	[97]
Naing *et al.*, 2016	Malaysia	Mixed	Cohort	7038	≥30	Hypertension	66.0		12.0		[98]
Oteh *et al.*, 2011	Malaysia	Urban	Cross-sectional	950	≥30	Hypertension				48.5	[99]
Pan *et al.*, 2020	Taiwan	Mixed	Cross-sectional	26440	≥20	Hypertension		81.0	63.1		[100]
Pang *et al.*, 2010	China	Rural	Cross-sectional	6059	≥60	Hypertension	35.2	28.7	3.7	1.0	[101]
Porapakkham *et al.*, 2008	Thailand	Mixed	Cross-sectional	10365	≥60	Hypertension	43.9				[17]
Prenissl *et al.*, 2019	India	Mixed	Cross-sectional	125609	≥20	Hypertension	44.3	13.3	7.7		[102]
Qiao *et al.*, 2013	China	Did not report	Cohort	1859	≥20	Hypertension	27.5	19.1		6.0	[103]
Roy *et al.*, 2017 (Survey 1)	India	Mixed	Cross-sectional	5510	35–64	Hypertension	37.5	32.0		14.4	[104]
Roy *et al.*, 2017 (Survey 2)	India	Mixed	Cross-sectional	3940	35–64	Hypertension	38.7	32.3		12.8	[104]
Ruixing *et al.*, 2008	China	Did not report	Cross-sectional	446	≥35	Hypertension	10.1	6.7	43.4		[105]
Saju *et al.*, 2020	India	Urban	Cohort	427	≥30	Hypertension	78.0				[106]
Sathish *et al.*, 2012	India	Mixed	Cohort	70	15–64	Hypertension	42.9	22.9	14.2		[107]
Satoh *et al.*, 2017	Japan	Mixed	Cross-sectional	1282	≥20	Hypertension	66.9	56.2	38.9		[108]
Sheng *et al.*, 2013	China	Mixed	Cross-sectional	2345	≥60	Hypertension	72.5	65.8	24.4		[109]
Singh *et al.*, 2011	India	Mixed	Cross-sectional	3433	≥25	Hypertension	39.2	19.5	33.4		[110]
Singh *et al.*, 2017	India	Urban	Cross-sectional	211	25–64	Hypertension	38.4				[111]
Sui *et al.*, 2013	China	Did not report	Cross-sectional	25336	35–85	Hypertension		97.7		40.2	[112]
Sun *et al.*, 2007	China	Rural	Cross-sectional	17360	≥35	Hypertension	29.5	23.6	4.8	1.1	[113]
Sun *et al.*, 2010	China	Rural	Longitudinal study	6458	≥35	Hypertension	29.9	19.5		1.6	[114]
Thankappan *et al.*, 2006	India	Rural	Cross-sectional	1810	≥30	Hypertension	24.4	19.7	32.3	6.4	[115]
Thankappan *et al.*, 2013	India	Rural	Community-based intervention	4627	25–74	Hypertension	23.6	18.9		6.5	[116]
Tian *et al.*, 2011	China	Urban	Cross-sectional	7237	18–74	Hypertension	42.9	28.2	12.9	3.6	[117]
Tripathy *et al.*, 2017b	India	Mixed	Cross-sectional	2030	≥18	Hypertension		30.1	61.0		[118]
Wang *et al.*, 2004	China	Mixed	Cross-sectional	13504	35–59	Hypertension	24.5				[119]
Wang *et al.*, 2013	China	Mixed	Cross-sectional	5227	≥18	Hypertension	54.3	46.3		18.3	[120]
Wang *et al.*, 2018	China	Mixed	Cross-sectional	126040	≥18	Hypertension	51.6	45.8	36.7	16.8	[121]
White *et al.*, 2009	Australia	Rural	Cross-sectional	449	23–93	Hypertension	43.4	45.0			[122]

†Control rate based on treatment rate.
‡Control rate based on the sample diagnosed.

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Table 3. Summary of included studies (cont.).

Study, year	Country	Area	Study design	Sample size, n	Age, years	Risk factor	Awareness rate	Treatment rate	Control rate†	Control rate‡	Ref.
Wu *et al.*, 2015	China	Urban	Cross-sectional	1409	≥60	Hypertension	75.1	67.1	29.6		[123]
Wu *et al.*, 2014	China	Mixed	Cross-sectional	5019	≥25	Hypertension	58.3	52.3	23.4		[124]
Xing *et al.*, 2019a	China	Mixed	Cross-sectional	6623	≥40	Hypertension	47.5	35.4	10.1	3.6	[125]
Xing *et al.*, 2019b	China	Mixed	Cross-sectional	10676	≥40	Hypertension	48.5	38.0	14.9	5.7	[126]
Yang *et al.*, 2010	China	Rural	Cross-sectional	6171	35–74	Hypertension	52.4	38.3	7.2		[127]
Yang *et al.*, 2014	China	Mixed	Cross-sectional	10644	≥60	Hypertension	46.3	50.3		34.5	[128]
Yang *et al.*, 2016	China	Mixed	Cross-sectional	4410	≥40	Hypertension	70.9	59.2	32.6		[129]
Yin *et al.*, 2016	China	Mixed	Cross-sectional	5514	≥45	Hypertension	59.0	46.4	24.7		[130]
Yongqing *et al.*, 2016	China	Mixed	Cross-sectional	3146	18–69	Hypertension	31.4				[131]
You *et al.*, 2018a	China	Mixed	Longitudinal study	8125	≥45	Hypertension	38.7	43.0		9.9	[132]
You *et al.*, 2018b	China	Mixed	Cross-sectional	3992	≥45	Hypertension	53.1	43.4	10.0		[133]
Yuvaraj *et al.*, 2010	India	Rural	Cross-sectional	349	≥18	Hypertension	33.8	32.1	12.5		[134]
Zhang *et al.*, 2009	China	Urban	Cross-sectional	2009	≥60	Hypertension	75.3	66.7	48.2	32.1	[135]
Zhang *et al.*, 2017	China	Mixed	Cross-sectional	2335	≥40	Hypertension	50.1	39.0	11.0		[136]
Zhao *et al.*, 2019	China	Mixed	Cross-sectional	4874	≥45	Hypertension	68.0	61.1		27.2	[137]
Zhao *et al.*, 2012	China	Did not report	Cross-sectional	11993	≥18	Hypertension	49.2	43.3	7.1		[138]
Zhou *et al.*, 2019 (previous guideline: ≥140/90 mm Hg)	China	Did not report	Cross-sectional	20454	18–98	Hypertension	44.3	32.5		13.0	[139]
Zhou *et al.*, 2019 (new guideline: ≥130/80 mm Hg)	China	Did not report	Cross-sectional	34459	18–98	Hypertension	26.3	19.3		2.7	[139]
Gao *et al.*, 2016	China	Mixed	Cross-sectional	5126	≥40	Diabetes mellitus	36.3	27.9	34.7		[140]
Goswami *et al.*, 2016	India	Urban	Cross-sectional	167	≥60	Diabetes mellitus		62.3	33.6		[13]
Gupta *et al.*, 2020	India	Rural	Cross-sectional	81	≥60	Diabetes mellitus	45.7				[14]
Ho *et al.*, 2014	Malaysia	Mixed	Cross-sectional	2708	≥60	Diabetes mellitus	35.0	22.8	76.5		[141]
Hu *et al.*, 2008	China	Mixed	Cross-sectional	986	35–74	Diabetes mellitus	28.5	24.7	38.1		[142]
Hu *et al.*, 2017b	China	Mixed	Cross-sectional	655	≥18	Diabetes mellitus	52.5	41.8		19.1	[143]
Li *et al.*, 2019c	China	Rural	Cross-sectional	533	≥45	Diabetes mellitus	51.8	38.6	14.1		[144]
Li *et al.*, 2019c	China	Mixed	Longitudinal study	1703	≥45	Diabetes mellitus	33.4	23.6			[80]
Liu *et al.*, 2016	China	Urban	Cross-sectional	521	≥60	Diabetes mellitus	78.5	69.3	18.8	15.9	[145]
Liu *et al.*, 2020	China	Mixed	Cross-sectional	609	≥40	Diabetes mellitus	82.3				[146]
Porapakkham *et al.*, 2008	Thailand	Mixed	Cross-sectional	2999	≥60	Diabetes mellitus	58.8				[17]

†Control rate based on treatment rate.
‡Control rate based on the sample diagnosed.

Table 3. Summary of included studies (cont.).

Study, year	Country	Area	Study design	Sample size, n	Age, years	Risk factor	Awareness rate	Treatment rate	Control rate†	Control rate‡	Ref.
Qin *et al.*, 2016	China	Mixed	Cross-sectional	499	18–80	Diabetes mellitus	28.1	25.9	48.1		[147]
Tripathy *et al.*, 2017a	India	Mixed	Cross-sectional	207	≥18	Diabetes mellitus		18.0	35.0		[148]
Wang *et al.*, 2014	China	Mixed	Cross-sectional	1854	18–79	Diabetes mellitus	67.2	57.0	44.1		[149]
Xi *et al.*, 2020	China	Mixed	Cross-sectional	13644	35–75	Diabetes mellitus		30.8		4.7	[150]
Xu *et al.*, 2013	China	Mixed	Cross-sectional	11444	≥18	Diabetes mellitus	30.1	25.8	39.7		[151]
Yan *et al.*, 2020	Thailand	Mixed	Cross-sectional	10497	≥20	Diabetes mellitus	34.0	33.3	26.0		[152]
Ye *et al.*, 2016	China	Mixed	Cohort	3803	≥35	Diabetes mellitus	68.1	63.5	35.1		[153]
Zhang *et al.*, 2012	China	Mixed	Cross-sectional	753	≥18	Diabetes mellitus	12.9				[154]
Cai *et al.*, 2012a	China	Mixed	Cross-sectional	2043	18–79	Dyslipidemia	22.0				[155]
He *et al.*, 2014	China	Mixed	Cross-sectional	7319	18–79	Dyslipidemia	11.6	8.4	34.8		[156]
Ho *et al.*, 2018	Australia	Did not report	Cohort	4257	65–84	Dyslipidemia		15.2			[141]
Ni *et al.*, 2015	China	Urban	Cross-sectional	691	20–96	Dyslipidemia	25.0				[157]
Pan *et al.*, 2016	China	Mixed	Cross-sectional	15801	>18	Dyslipidemia	31.0	19.5		8.5	[158]
Song *et al.*, 2019	China	Mixed	Cross-sectional	4081	≥45	Dyslipidemia	20.3	14.4	34.3		[159]
Wang *et al.*, 2011	China	Mixed	Cross-sectional	1654	45–89	Dyslipidemia	50.9	23.8	39.9		[160]
Xing *et al.*, 2020	China	Mixed	Cross-sectional	6712	≥40	Dyslipidemia	14.7	5.9		2.9	[161]
Khoo *et al.*, 2013	Singapore	Mixed	Cross-sectional	2445	24–95	Hypercholesterolemia (LDL-c)	30.8				[162]
Kim *et al.*, 2020a	South Korea	Did not report	Cohort	69942	40–79	Hypercholesterolemia (LDL-c)				47.6	[163]
Lu *et al.*, 2018	China	Did not report	Longitudinal study	2189	45–75	Hypercholesterolemia (LDL-c)	37.7	31.1		26.5	[16]
Momo *et al.*, 2019	Japan	Did not report	Cohort	294	≥60	Hypercholesterolemia (LDL-c)				45.9	[164]
Wu *et al.*, 2017 (before 2013 ACC/AHA guideline)	China	Did not report	Cross-sectional	1521	18–75	Hypercholesterolemia (LDL-c)				27.7	[165]
Wu *et al.*, 2017 (after 2013 ACC/AHA guideline)	China	Did not report	Cross-sectional	2071	18–75	Hypercholesterolemia (LDL-c)				26.6	[165]

†Control rate based on treatment rate.
‡Control rate based on the sample diagnosed.

Table 4. Overall pooled awareness, treatment, and control rates for each risk factor.

Risk factor†	Outcome‡ S	Studies (n)	Pooled rate (%)	95% CI	I^2 (%)
Diabetes mellitus	Awareness rate	19	46	[38; 55]	99.6
	Treatment rate	19	37	[31; 43]	99.5
	Control rate among those treated for diabetes mellitus	19	15	[10; 21]	99.5
	Control rate among those with diabetes mellitus	13	12	[03; 26]	99.0
Dyslipidemia	Awareness rate	7	24	[16; 33]	99.7
	Treatment rate	8	14	[09; 20]	99.6
	Control rate among those treated for dyslipidemia	7	5	[03; 09]	98.3
	Control rate among those with dyslipidemia	7	5	[01; 12]	99.7
Hypercholesterolemia	Awareness Rate	4	51	[26; 76]	99.7
	Treatment Rate	3	31	[29; 33]	NA
	Control Rate among Those with Hypercholesterolemia	5	35	[23; 47]	99.6
Hypertension	Awareness Rate	113	47	[45; 49]	99.8
	Treatment Rate	116	40	[36; 44]	100.0
	Control Rate among Those Treated for hypertension	116	13	[10; 18]	100.0
	Control Rate among Those with Hypertension	107	13	[11; 16]	99.9

†See Table 1 for definitions.
‡See Table 2 for definitions.
CI: Confidence interval.

interest, the control rates remain suboptimal for dyslipidemia (5%, 95% CI: 3–9%), for hypertension (13%, 95% CI: 11–16%) and for diabetes mellitus (15%, 95% CI: 10–21%). No published population-/community-based study was identified for the control rate among those being treated with medications for hypercholesterolemia. However, interpretations of these pooled outcomes should be with cautious due to substantial heterogeneity.

Subgroup analysis

Table 5 and Table 6 show pooled awareness, treatment and control rates by country/region or by the living area, respectively. Subgroup analyses suggested statistically significant differences in pooled awareness rates across countries/regions ($p = 0.0339$ for diabetes mellitus, $p < 0.001$ for hypercholesterolemia and hypertension). Pooled awareness rates also significantly varied by the living areas for hypercholesterolemia ($p < 0.001$), diabetes mellitus ($p < 0.001$) and hypertension ($p = 0.006$). Statistically significant differences in pooled treatment rates were found for diabetes mellitus and hypertension across countries/regions and by living area (all $p < 0.001$). In individuals with the risk of interest, the control rates were statistically different across countries/regions for hypercholesterolemia and hypertension (both $p < 0.001$). Those treated with medications for diabetes mellitus and hypertension had significant different pooled control rates by country/region and by living areas (all $p < 0.001$).

Assessment of biases

The Egger's tests showed no statistical significance and thus suggest lack of evidence for significant publication bias for awareness rates ($p = 0.257$), treatment rates ($p = 0.551$), control rates among those being treated ($p = 0.381$), and control rates among those with the risk factor of interest ($p = 0.273$). Supplementary Figures 1–4 present associated funnel plots. Supplementary Table 3 presents the detailed results of the quality assessment per the NOS. Among 138 studies being assessed, 8% of the studies had very good quality, 79.8% had good quality, 10.8% had satisfactory quality, and 1.4% had unsatisfactory quality.

Discussion

This study systematically reviewed published real-world evidence from population- or community-based studies and generated pooled estimates of awareness, treatment, and control rates as proxies to indicate how dyslipidemia, hypertension and diabetes mellitus as cardiovascular risk factors were managed in general adult populations in 11 APAC countries/regions. The total sample sizes and the number of countries/regions covered in this SLR represent a strength. Overall, study results suggested management of hypertension, dyslipidemia and diabetes mellitus was suboptimal in these 11 countries/regions, evidenced by relatively low pooled rates shown in Table 4.

Table 5. Pooled awareness, treatment and control rates by country/region.

Risk factor	Outcome	Studies (n)	Pooled rate (%)	95% CI	Test for subgroup differences (p-value)
Diabetes mellitus	Awareness rate				
	China	13	47	[36; 59]	0.0339
	India	3	46	[35; 57]	
	Malaysia	1	35	[33; 37]	
	Thailand	2	46	[23; 70]	
	Treatment Rate				
	China	13	39	[30; 47]	<0.0001
	India	3	39	[04; 82]	
	Malaysia	1	23	[21; 24]	
	Thailand	2	33	[32; 34]	
	Control rate among those treated for diabetes mellitus				
	China	13	14	[08; 22]	<0.0001
	India	3	13	[02; 30]	
	Malaysia	1	17	[16; 19]	
	Thailand	2	26	[25; 27]	
	Control rate among those with diabetes mellitus				
	China	13	12	[03; 26]	1.000
Dyslipidemia	Awareness Rate				
	China	7	24	[16; 33]	1.000
	Treatment Rate				
	China	7	14	[08; 21]	0.6531
	Australia	1	15	[14; 16]	
	Control rate among those treated for dyslipidemia				
	China	7	5	[03; 09]	1.000
	Control rate among those with dyslipidemia				
	China	7	5	[01; 12]	1.000
Hypercholesterolemia	Awareness Rate				
	Singapore	1	64	[62; 66]	<0.0001
	China	3	38	[36; 40]	
	Treatment Rate				
	China	3	31	[29; 33]	1.000
	Control rate among those with hypercholesterolemia				
	South Korea	1	48	[47; 48]	<0.0001
	China	3	27	[26; 28]	
	Japan	1	46	[40; 52]	
Hypertension	Awareness Rate				
	Malaysia	6	48	[35;60]	<0.0001
	Thailand	4	55	[43;67]	
	Australia	6	66	[50;81]	
	India	24	40	[36;44]	
	China	68	47	[44;50]	
	South Korea	3	60	[58;68]	
	Singapore	1	70	[68;71]	
	Japan	1	67	[64;69]	
	Treatment Rate				
	Malaysia	6	33	[25;42]	<0.0001
	Thailand	4	69	[33;95]	
	Australia	6	66	[53;78]	
	India	24	28	[23;34]	
	China	68	39	[35;44]	
	Philippines	1	66	[65;66]	

CI: Confidence interval.

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Table 5. Pooled awareness, treatment and control rates by country/region (cont.).

Risk factor	Outcome	Studies (n)	Pooled rate (%)	95% CI	Test for subgroup differences (p-value)
	South Korea	3	16	[14;19]	
	Taiwan	2	81	[81;81]	
	Singapore	1	68	[66;70]	
	Japan	1	56	[53;59]	
	Control rate among those treated for hypertension				
	Malaysia	6	9	[07;12]	<0.0001
	Thailand	4	12	[11;12]	
	Australia	6	28	[07;57]	
	India	24	8	[06;09]	
	China	68	12	[09;16]	
	Philippines	1	38	[38;39]	
	South Korea	3	39	[00;95]	
	Taiwan	2	51	[50;52]	
	Singapore	1	23	[21;24]	
	Japan	1	20	[20;24]	
	Control rate among those with hypertension				
	Malaysia	6	21	[07;40]	<0.0001
	Thailand	4	24	[24;26]	
	India	24	9	[09;16]	
	China	68	9	[09;15]	
	South Korea	3	15	[15;17]	
	Taiwan	2	61	[61;65]	

CI: Confidence interval.

In comparisons of the same measure among risk factors in Table 4, the low number of studies and the lowest pooled rates for dyslipidemia suggested that dyslipidemia received the least attention. In comparisons between diabetes mellitus and hypertension, most pooled rates were numerically similar and indicated no statistical difference (evidenced by overlapped CIs of pooled estimates), which suggested a similar level of disease management for diabetes mellitus and hypertension. Hypercholesterolemia had a similar level of awareness rate compared with diabetes mellitus and hypertension. Interestingly, individuals with hypercholesterolemia had a statistically lower pooled treatment rate but a higher pooled control rate (i.e., non-overlapped CIs) than those with hypertension. A similar pattern was observed between hypercholesterolemia and diabetes mellitus, but CIs were overlapped, and no statistical difference could be claimed. Nevertheless, all pooled rates were still relatively low, which suggested there was still room to improve management of these risk factors for the general adult populations in these 11 countries/regions.

Awareness of the presence of diabetes mellitus, hypertension, dyslipidemia and hypercholesterolemia plays an important role its prevention [18–20], as it would lead individuals with these risk factor(s) to seek medical attention and, in turn, trigger necessary disease self-management and proper treatments [21,22]. However, relatively low awareness rates found in this study are alerting to indicate that the general adult populations in these countries/regions may miss opportunities to medical attention and proper disease management to treat and control for these cardiovascular risk factors [18,23]. Unawareness of a cardiovascular risk factor may be due to multiple reasons, such as levels of education. For example, a study indicated that people with lower levels of education were more likely to exhibit lower sensitivity to self-report hypercholesterolemia [24].

Treatment and control rates are important indicators of cardiovascular risk factor management. Low pooled treatment and control rates reported in this study also raise a concern about under treated and under control of diabetes mellitus, hypertension, dyslipidemia and hypercholesterolemia in the general adult populations in these 11 countries/regions. A study also reported low treatment and control rates for hypertension even for those with very high risk of future cardiovascular events [25]. The suboptimal management of these cardiovascular risk factors could substantially impact the cost of illness, years of life lost and productivity-adjusted life years (PALYs) lost across the working lifetime [26].

Table 6. Pooled awareness, treatment and control rates by area.

Risk factor	Outcome by area	Studies (n)	Pooled rate (%)	95% CI	Test for subgroup differences (p-value)
Diabetes mellitus	Awareness rate				
	Mixed	15	43	[35; 52]	<0.0001
	Urban	2	79	[75; 82]	
	Rural	2	51	[47; 55]	
	Treatment Rate				
	Mixed	15	33	[26; 39]	<0.0001
	Urban	2	66	[60; 73]	
	Rural	2	39	[34; 43]	
	Control Rate among Those Treated for Diabetes Mellitus				
	Mixed	15	16	[10; 23]	<0.0001
	Urban	2	16	[09; 25]	
	Rural	2	5	[03; 07]	
	Control Rate among Those with Diabetes Mellitus				
	Mixed	15	11	[01; 29]	0.9377
	Urban	2	16	[13; 19]	
Dyslpidemia	Awareness Rate				
	Mixed	6	24	[15; 34]	0.9877
	Urban	1	25	[22; 28]	
	Treatment Rate				
	Mixed	6	14	[08; 21]	0.9039
	Not reported area	1	15	[14; 16]	
	Control Rate among Those Treated for Dyslipidemia				
	Mixed	6	5	[03; 09]	1.000
	Control Rate among Those with Dyslipidemia				
	Mixed	6	5	[01; 12]	1.000
Hypercholesterolemia	Awareness Rate				
	Mixed	1	64	[62; 66]	<0.0001
	Not reported area	5	38	[36; 40]	
	Treatment Rate				
	Not reported area	5	31	[29; 33]	1.000
	Control Rate among Those with Hypercholesterolemia				
	Not reported area	5	35	[23; 47]	1.000
Hypertension	Awareness Rate				
	Mixed	54	42	[37;46]	0.0006
	Not reported area	18	45	[32;58]	
	Urban	18	49	[40;59]	
	Rural	26	27	[21;32]	
	Treatment Rate				
	Mixed	54	33	[26; 39]	<0.0001
	Urban	18	66	[60; 73]	
	Rural	26	39	[34; 43]	
	Control Rate among Those Treated for Hypertension				
	Mixed	54	13	[10;16]	<0.0001
	Not reported area	18	23	[12;36]	
	Urban	18	23	[13;35]	
	Rural	26	4	[03;06]	
	Control Rate among Those with Hypertension				
	Mixed	54	14	[11;17]	0.2343
	Not reported area	18	14	[04;28]	
	Urban	18	18	[09;30]	
	Rural	26	9	[05;14]	

CI: Confidence interval.

Based on results of subgroup analysis, we found significant differences in some pooled rates by country/region (Table 5) or by living area (Table 6), which suggested that, overall, these risk factors were managed differently and perhaps received different levels of attention across countries/regions and/or living areas. For example, concerning dyslipidemia, we found a greater number (in absolute terms, not significant) of studies conducted in China reporting awareness, treatment and control rates for dyslipidemia and hypercholesterolemia. Despite the limited data, the prevalence of hypercholesterolemia in China was reported to be relatively high and the percentage of adults aware of the disease and with controlled blood cholesterol was low [27]. Results from this study showed pooled control rate among individuals with hypercholesterolemia was lower in China than in Japan or South Korea. This suggests unmet need for hypercholesterolemia and dyslipidemia care in China. Improved management of dyslipidemia and hypercholesterolemia should be considered as an important component of a national public health strategy to reduce the substantial and increasing burden of cardiovascular disease in China. A SLR by Alabousi and colleagues [5] showed twofold or higher rates (awareness rates: 81%–84% for hypertension; 43%–63% for dyslipidemia; and 84%–88% for diabetes mellitus; treatment rates: 72%–82% for hypertension; 20%–44% for dyslipidemia; 80%–87% for diabetes mellitus; control rates: 48%–68% for hypertension; 42%–65% for dyslipidemia; 35%–59% for diabetes mellitus) in the US and Canada in comparison with the findings in our study. This suggests more efforts should be added to improve management of hypertension, dyslipidemia and diabetes mellitus in our target Asian countries.

Concerning the diversity by living area, we observed that, in general, pooled rates were either statistically or numerically higher in urban area than other types of living areas for diabetes mellitus or hypertension. Another study reported inconclusive results about the prevalence of CVD risk factors in rural areas; however caution should be taken when interpreted this information due to the limited data [28]. It seems inconclusive whether urbanization impacts the environmental and lifestyle factors, and the individual health and well-being. The influence of urbanization on health can be mixed. On the one hand, there are the benefits of ready access to healthcare, sanitation, and secure nutrition, while on the other, there are the evils of overcrowding, pollution, social deprivation, crime, and stress-related illness [29]. In our study, the treatment rate of hypertensive individuals was greater in urban areas which may be attributed to a perspective of 'urban health advantage', that considers the special resources, protective effect of cities and emphasizes the positive aspects of cities in the management of the CVD risks factors [29].

It was estimated that 50% reduction from 14% to 7% in prevalence of hypertension from 2015 to 2030 would lead to 5% reduction in mortality in adults aged 30–69 years globally [30,31]. A modelling study estimated that public health interventions aiming to reduce cardiovascular risk factors would be cost-effective with return on investment (ROI) ranging from 15.0 to 27.5 in an at risk population [32]. Costs related to lost productivity attributable to CV risk factors were estimated in a range from $3.2 to 23.1 billion annually (2005 US Dollars) in the US [33]. However, publications that specifically demonstrate the impact of reaching WHO cardiovascular risk factor targets in real-world settings remain scarce. Nevertheless, more efforts to optimize management of hypertension, dyslipidemia, and diabetes mellitus are still required to achieve WHO-recommended targets of risk factors reduction [3,31]. To prioritize efforts to reach the WHO target, we recommend that decision-makers such as health professionals, health policymakers, and national taxpayers consider reallocating resources to make lipid control a national priority, in addition to existing priorities of hypertension and diabetes mellitus management.

Our study identified large gaps in important evidence needed to inform efforts at cardiovascular risk factor reduction in the APAC region. The numbers of studies from China allow proper interpretations of the pooled rates, but very few studies or no studies were identified in some countries/regions (e.g., Hong Kong, Malaysia, Singapore, and Taiwan). Wide ranges of awareness, treatment, and control rates as well as high heterogeneity for pooled estimates were observed in overall analysis of the risk factors. Several factors may have contributed to the high heterogeneity found in this SLR: considerable inherent diversity (e.g., socioeconomic status, population characteristics, cultural and behavioural differences) within the same country/region and across countries/regions, subgroups of populations investigated (e.g., treated *vs* non-treated, patients without CVD *vs* with history of CVD, different age groups), different definitions of the conditions (e.g., high blood pressure considered to be 130/80 mmHg or 140/90 mmHg), other factors not controlled or unobserved in most studies (e.g., behavioural factors, socioeconomic disparities), and/or diverse clinical practice of cardiovascular risk factor management in the various countries/regions. During our reviews of included studies, we found various definitions of hypertension, diabetes mellitus, and dyslipidemia (Table 1), which may partially explain the wide ranges of awareness rates. Unfortunately, the evidence across many countries/regions suggests discrepancies between clinical guidelines to control the CVD risk factors and actual clinical practice patterns in real-world settings [34].

Our study should be interpreted in light of some limitations. First of all, this meta-analysis included 11 countries/regions, but the majority of articles are from China, while scarce studies or virtually no study were found for some countries/regions; therefore, the results may not be generalizable to the entire APAC region. The second limitation is the considerable heterogeneity that is not fully explained. The heterogeneity could be attributed to different definitions, local guidelines or criteria used by researchers of included studies to define hypertension, dyslipidemia, and diabetes mellitus, to use different biomarkers, to decide which patients were treated, to include different types and durations of treatments and to determine how well conditions were controlled. The third limitation is that included articles have their specific methodological limitations, and the result of our meta-analysis comprehends these limitations. Funnel plots are traditionally constructed to facilitate assessment of publication bias, but could be potentially misleading in meta-analyses of proportions/rates [35]. Thus, despite the Egger's test leads to the failure to reject asymmetry in the funnel plot, subjectively the graphics demonstrate the opposite: in the top part of the plot the studies do not lie within the limits due to the greater number of studies with a large sample size.

Strengths of our study should also be highlighted. The data shown are from the general population or community-based, in addition to present features of a representative number of individuals, which enhance the findings. Additionally, this is the first SLR and meta-analysis that reviews and summarizes the awareness, treatment and control rates in these 11 Asian countries/regions.

Future public health policies and interventions must be designed in each country/region and take into consideration all those factors to promote health and achieve a considerable reduction in CVD cases. Yet, further comparative effectiveness research or prediction models would also be warranted to provide more insights and suggestions to guide resource allocation and prioritization among management of cardiovascular risk factors. Finally, these findings demonstrate the importance of health measures to prevent CVDs in APAC countries.

Future perspective

Effective and innovative strategies that would lead to better controls of hypertension, dyslipidemia, and diabetes mellitus are warranted in APAC countries/regions to achieve WHO-recommended targets for risk factor reduction. In addition to better hypertension and diabetes mellitus management, resources for the management of dyslipidemia including hypercholesterolemia should be given a greater priority. Evidence gaps were identified, particularly the need for data on awareness, treatment, and control rates of alcohol consumption, smoking, obesity, and physical inactivity.

Summary points

- The World Health Organization (WHO) recommended several targets to reduce risk factors to reduce 25% of premature deaths, including deaths from cardiovascular disease, by the year 2025. To prioritize efforts to reach WHO targets, the status of cardiovascular risk factor management must be understood; however, little is known in Asia–Pacific (APAC) countries/regions.
- Systematic literature reviews of 138 studies showed management of hypertension, dyslipidemia (including hypercholesterolemia) and diabetes mellitus in adults was generally suboptimal in 11 APAC countries/regions.
- Individuals with dyslipidemia received the least attention based on the lowest pooled awareness, treatment and control rates compared with other risk factors. Levels of awareness with diabetes mellitus, hypertension and hypercholesterolemia were comparable, but individuals with hypercholesterolemia had a statistically lower pooled treatment rate but a higher pooled control rate than those with hypertension. Variations and high heterogeneity were observed across risk factors, countries/regions, and living areas.

Supplementary data

To view the supplementary data that accompany this paper please visit the journal website at: https://bpl-prod.literatumonline.com/doi/10.57264/cer-2022-0085

Author contributions

EJ Yeh initiated the study concept and prepared the study protocol. All authors were involved in the design of the study and interpretations of results. RB Grigolon, APA Bueno and SR Rodrigues performed the identification and selection of articles. RB Grigolon and SR Rodrigues worked on data extraction. RB Grigolon performed the statistical analysis. APA Bueno prepared the first draft of the manuscript. EJ Yeh made substantial changes and finalize the manuscript.

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