Socioeconomic status and hypertension: a meta-analysis

Bing Leng*, Yana Jin*, Ge Li, Ling Chen, and Nan Jin

Background: The relationship between socioeconomic status (SES) and hypertension has been studied in a number of reviews. However, the impact of SES on hypertension has been reported in several studies with conflicting results.

Methods: A systematic search was performed in PubMed, Proquest and Cochrane databases for observational studies on hypertension prevalence and SES, published in English, until March 2014. Hypertension was defined as a mean SBP of at least 140 mmHg or a DBP of at least 90 mmHg, or use of antihypertensive medication. The inverse variance method with a random-effects model was used to pool the risk estimates from the individual studies. Data abstraction was conducted independently by two authors.

Results: Among the 2404 references, 51 studies fulfilled the inclusion criteria. An overall increased risk of hypertension among the lowest SES was found for all three indicators: income [pooled odds ratio (OR) 1.19, 95% confidence interval (CI) 0.96–1.48], occupation (pooled OR 1.31, 95% CI 1.04–1.64) and education (pooled OR 2.02, 95% CI 1.55–2.63). The associations were significant in high-income countries, and the increased risk of hypertension for the lowest categories of all SES indicators was most evident for women, whereas men revealed less consistent associations.

Conclusion: Low SES is associated with higher blood pressure, and this association is particularly evident in the level of education. It is important to identify and monitor hypertension to reduce the risk of this disease among the most vulnerable groups in different countries and among different societies.

Keywords: education, hypertension, income, meta-analysis, occupation, socioeconomic status

Abbreviations: OR, odds ratio; PRISMA, preferred reporting items for systematic reviews and meta-analyses; RR, risk ratio; SES, socioeconomic status

INTRODUCTION

Hypertension is a major risk factor for cardiovascular disease, and plays an important role in the development of stroke, myocardial infarction, heart failure and renal failure [1]. Globally, 54% of stroke and 47% of ischemic heart disease are attributable to high blood pressure. Overall, more than 80% of the attributable burden of disease was in low-income and middle-income regions [2].

There is a massive amount of evidence linking socioeconomic status (SES) with the conventional risk factor for hypertension [3–5]. The low-SES population is known to have a health-damaging lifestyle resulting in the development of poor dietary habits as well as influencing behaviors related to cigarette smoking and alcohol consumption [6], which led them to be exposed to numerous risk factors and, therefore, seem to have an obviously excessive burden of disease [7].

The relationship between SES and hypertension has been studied in a number of reviews. However, the impact of SES on the cardiovascular risk factor profile in general, and hypertension in particular, has been reported in several studies with conflicting results. Therefore, the present meta-analysis focused on the association between hypertension prevalence and various SES measures, including income, occupation categories and educational attainment.

METHODS

Search strategy

To identify eligible studies of associations between socioeconomic determinants and hypertension, we conducted a systematic search in PubMed, Proquest and Cochrane for articles published in English-speaking, peer-reviewed journals, until March 2014. For this search, we used key words related to socioeconomic determinants combined with hypertension.

Study selection

To be included in this meta-analysis, studies had to use original data; be designed as cross-sectional, case-control or cohort studies; consider hypertension prevalence as an outcome; present risk estimates with 95% confidence interval (CI) on the association between incident cases of hypertension and at least one measure of SES or report sufficient information to compute these for men, women or both.

Journal of Hypertension 2015, 33:221–229

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Received 12 June 2014 **Revised** 24 September 2014 **Accepted** 24 September 2014

DOI:10.1097/HJH.0000000000000428

Socioeconomic status indicators were included only if they were based on income, occupational categories or educational attainment. Studies utilizing a social indicator constructed as a combination of two or more standard socioeconomic indicators were not included. Neither did we include studies in which the SES measure was based on ownership of car/houses/health insurance or was presented as categories of deprivation. Only studies with an adult individual-level measure of SES were included. No restrictions were made by the type of SES – personal or household.

Regarding multiple studies on the same dataset, only the study with the most detailed information was included, preferring larger sample sizes and longer follow-up periods. Two investigators (B.L. and Y.J.) independently extracted relevant studies following the inclusion criteria. If necessary, the corresponding authors of the eligible studies were contacted and asked to provide additional information. Discrepancies were resolved by consensus in a panel meeting (L.C., B.L. and Y.J.).

Data extraction

All data were abstracted independently by two investigators (B.L. and Y.J.). The following information was extracted from each publication: the first author's name, the year of publication, country of origin of the studies, study design, years of data collection in cross-sectional and case-control studies, follow-up duration in cohort studies, sample size and characteristics (age and sex), indicators of SES, definition and status of the outcome, status of event, unadjusted and adjusted effect estimates and 95% CIs, and variables used in multivariable analysis. The information on country where the study was performed was classified according to the geographical area and the country's income level defined by the World Bank [8]. If adjusted effect estimates were given at different levels of adjustment, the most adjusted one was selected.

Statistical analysis

Odds ratio (OR) was used as the measure for the summary statistic of associations between SES and hypertension. To augment comparability between the studies using different SES categories, we compared the lowest with the highest SES category. For the original study reported, the risk estimates not in this order, the point estimate and 95% CI were back-calculated. If the articles reported estimates not in the form of OR, we recalculated the risk estimates and 95% CI from the raw data by using standard equations. If the original study reported separate OR for different sexes or different races, the risk estimates were pooled to obtain a single estimate per SES from each study. The pooled OR (and 95% CI) was estimated with a random-effect model, weighting for the inverse of the variance. In order to understand the information of the included studies more comprehensively, rate difference was reported for a supplement measure [9].

Subgroup analysis was conducted to examine potential sources of heterogeneity according to: region, country's income level, sex, mean age, type of adjustment with respect to hypertension risk factors, type of design and sample size. Random-effect meta-regression analyses were also performed to identify study-level factors contributing to heterogeneity between studies.

Heterogeneity between studies was tested with the Q test ($P < 0.10$ indicating a statistically significant heterogeneity) and the I^2 statistic (larger values showing the increasing heterogeneity, with 25% as low, 50% as moderate and 75% as high heterogeneity between studies) [10]. Publication bias, which may favor studies with significant findings, was ascertained by visual inspection of funnel plots. All statistical analyses were performed using STATA version 12. P values that were less than 0.05 were considered statistically significant. All statistical tests were two-sided.

RESULTS

Study characteristics

A total search in the electronic databases and hand search revealed 2404 references, and among those, 544 were overlapping between different search categories. The search strategy for the 1860 unique references is presented in Fig. 1 as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement flowchart. Briefly, 1689 articles did not address the issue of interest and were excluded after screening the abstracts, leaving us with 171 full-text articles for further examination. After full review, only 47 articles [3,6,11–55] fulfilled the predefined inclusion criteria and were selected to be included in the analysis. Of these, 34 articles [3,6,11–28,31–34,36–38,40,45,49–51,53,54] reported by raw data, and 13 articles [29,30,35,39,41–44,46–48,52,55] reported by ORs only.

Sub-studies from the articles by Kaplan *et al.* [31], originated from Canada [Mark S. Kaplan (A)] and the United States [Mark S. Kaplan (B)], were included independently. Similar to that, the same strategy was applied to data derived from the articles by Banks *et al.* [16], in which income and educational SES were presented among participants at the age of 55–64 years in England [James Banks (A1)] and in the United States [James Banks (A2)], and 40–70 years in England [James Banks (B1)] and in the United States [James Banks (B2)]. Therefore, we finally included 51 original studies from 47 articles in the analysis.

In total, there were two case–control studies in two articles [39,55] reporting associations with different SES among 1016 cases and 1016 controls. Seventeen cohort studies in 14 articles [3,11,16,17,22–24,30,34,35,38,40,42,50] were studied for 48 877 patients among 240 783 participants, and 32 cross-sectional studies in 31 articles [6,12–15,18–21,25–29,31–33,36,37,39,41,43–49,51–54] with 41 199 hypertension cases among 138 958 participants. Table 3 (online only, http://links.lww.com/HJH/A437) presents data on detailed study characteristics of the included studies.

Overall result

The overall results of this meta-analysis provided evidence of an increase in the risk of hypertension among the lowest socioeconomic categories for all three socioeconomic indicators (Figs. 2–4). Heterogeneity was observed for all three SES indicators ($P < 0.001$).

We observed a 19% increased prevalence of hypertension for the lowest-income group (OR 1.19, 95% CI

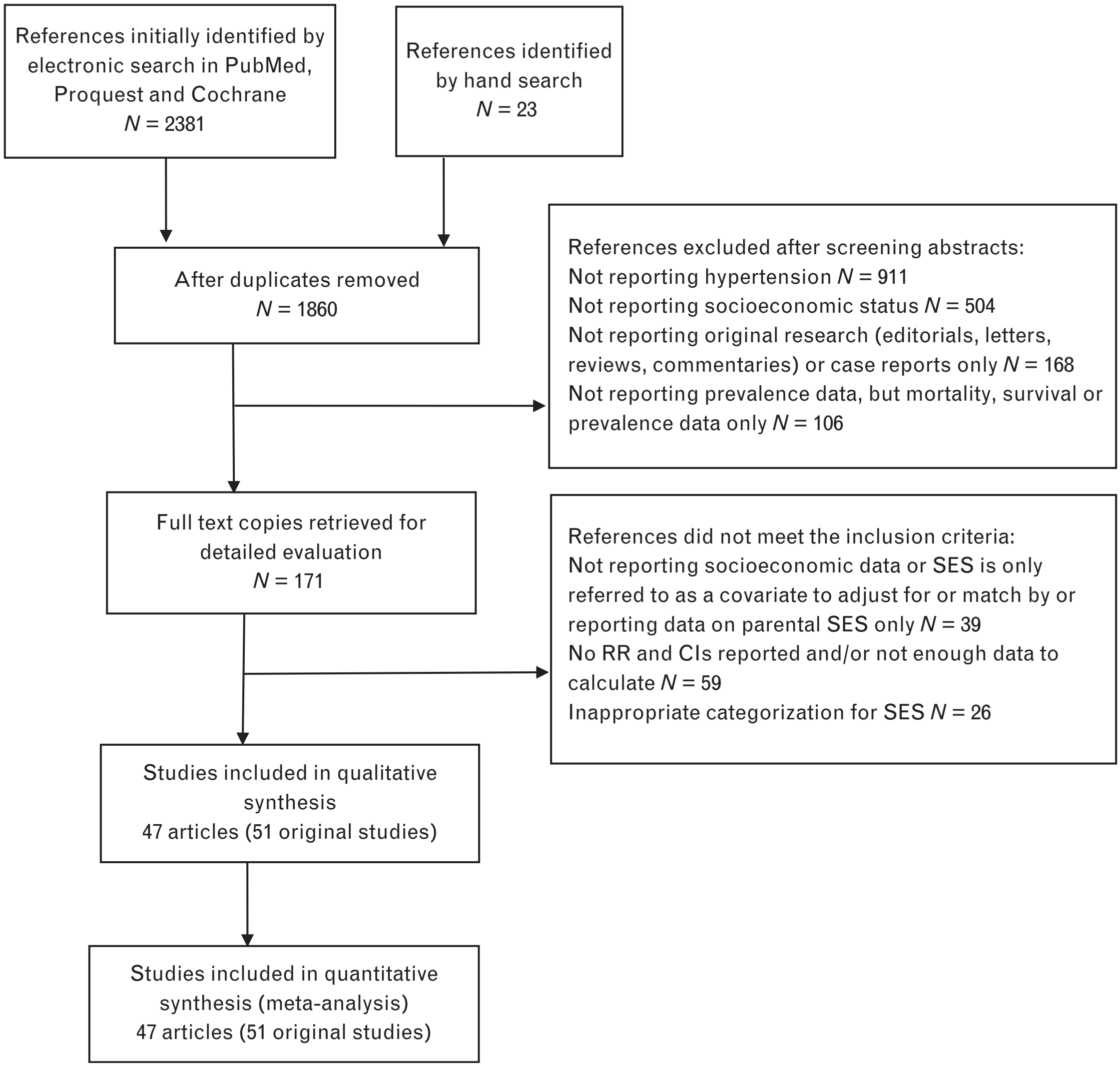

FIGURE 1 Flow diagram for selection of studies.

0.96–1.48; Table 1). After stratifying on the basis of the main study characteristics, region, country's income, sex and so on, the increase was apparent in the sub-analysis. An increased risk of hypertension was observed when studies on occupational categories were pooled (OR 1.31, 95% CI 1.04–1.64; Table 1).

The strongest pattern was observed for the lowest educational group which was twice as likely to be hypertensive (OR 2.02, 95% CI 1.55–2.63; Table 1) compared with the highest. Further stratification by region, country's income, sex, design or sample size did not alter the overall pooled results.

The increased prevalence of hypertension was evident for the lowest education-based, income and occupational SES in high-income countries and in regional areas such as the USA/Canada and Europe (Table 1). On the contrary, an inverse association was observed for the results combined across the studies on income and occupational SES in Africa.

There was a substantial heterogeneity after subgroup analysis. However, heterogeneity was reduced when analyses were restricted to studies originated from the USA/Canada. A similar result was seen when studies on high-income country were analyzed separately. In random-effect meta-regression analyses, the mean age was significantly associated with hypertension in studies on income ($\beta = 1.30$, 95% CI 1.01–1.68, $P = 0.045$). No other study-level characteristics for any of the SES indicators were found significant in meta-regression analyses (Tables S1–S3 in SDC, http://links.lww.com/HJH/A438).

Table 2 shows the pooled effect size by raw data, and the results were: income (OR 1.18, 95% CI 0.88 to 1.59; rate difference 5.2%, 95% CI 1.4 to 9.0%), occupation (OR 1.26, 95% CI 0.95 to 1.68; rate difference 4.9%, 95% CI −1.0 to 10.8%), and education (OR 2.15, 95% CI 1.56 to 2.97; rate difference 13.4%, 95% CI 10.2 to 16.6%).

No publication bias was found by Egger's test for income and occupational SES indicator (income $P = 0.68$, occupation $P = 0.30$), whereas educational SES introduced publication bias ($P = 0.02$), suggesting that small studies with negative results may not have been published (Figs. S1–S3 in SDC, http://links.lww.com/HJH/A438). No individual studies significantly altered the overall estimates based on the results of the sensitivity analysis.

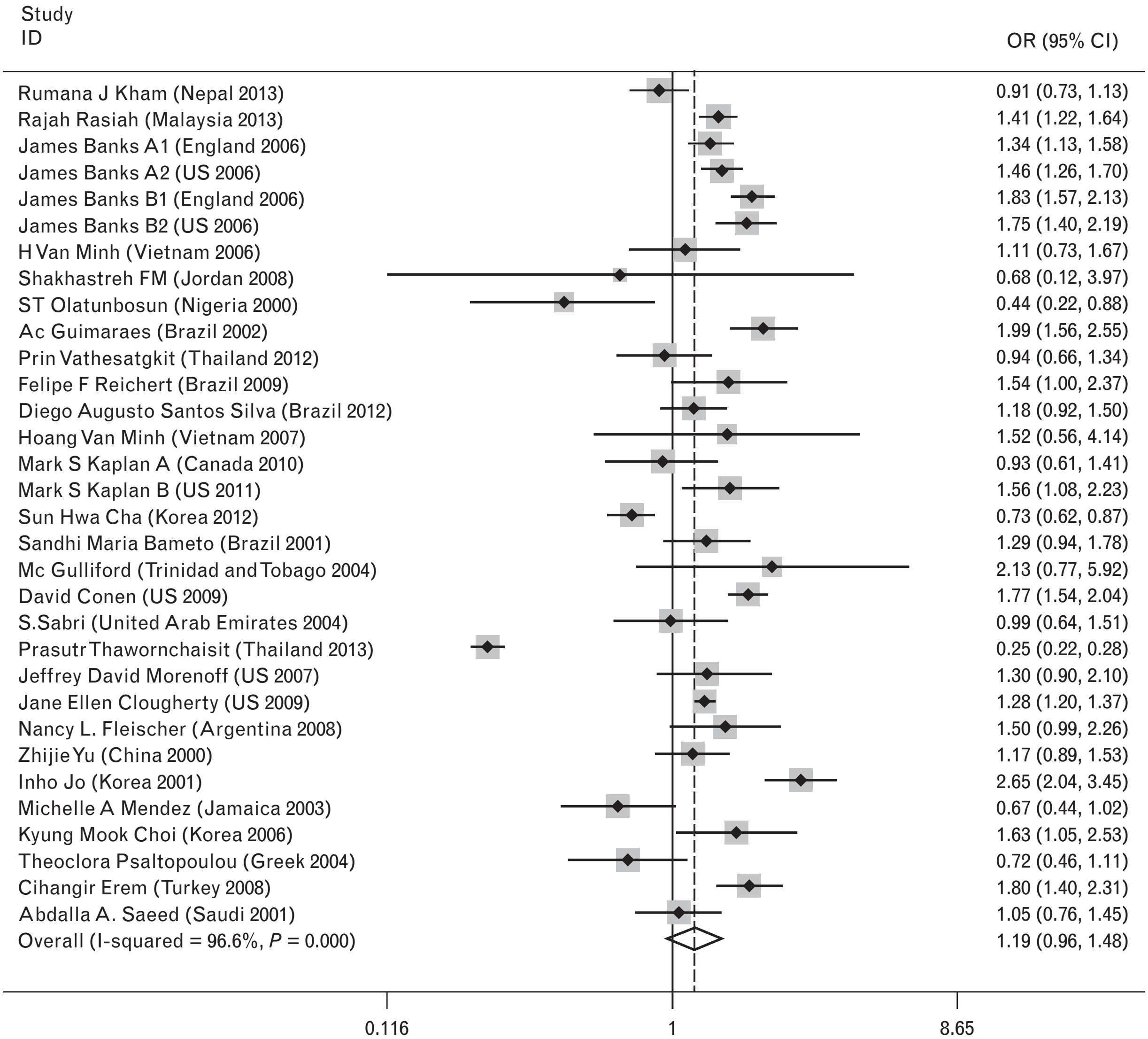

FIGURE 2 Forest plot of income categories and risk of hypertension prevalence. OR and 95% CI for hypertension prevalence and income categories (the lowest vs. the highest socioeconomic status category) in individual studies and for all studies combined. OR from the individual studies are indicated by squares and the size of the squares represents the statistical weight that each study contributed to the random-effect summary estimate. Horizontal lines indicate the study-specific 95% CI. Diamond represents the overall summary OR and its 95% CI. CI, confidence interval; OR, odds ratio.

DISCUSSION

Our results indicated an increased prevalence of hypertension among the lowest SES in income, occupation and education compared with the highest SES. The associations were significant in high-income countries. And the increased risk of hypertension for the lowest categories of all SES indicators was most evident for women, whereas men revealed less consistent associations. Compared with the results represented by ORs, the results pooled by raw data were almost the same qualitatively. However, the relative increase in the prevalence of hypertension was not obviously, especially in income, it was only 19%. Due to the large prevalence of this disease condition, prevalence under different SES may be close. In this case, if only OR was reported, this could have narrowed the practical impact. These seemingly subtle differences might make people ignore the negative impact of low SES on health. Therefore, rate difference was also reported, and the results were stronger than OR.

Meta-regression analyses indicate mean age as potential sources of heterogeneity between studies for income SES indicators. With increasing age, the association between low income and the prevalence of hypertension was likely more significant. However, the mean age was used as a basis for grouping, rather than the true age; the result should be interpreted with caution since the relationship with patient averages across studies may not be the same as the relationship for patients within studies [56].

In this meta-analysis, education was the most important SES indicator, which was observed to have the strongest association with the prevalence of hypertension. Level of education is usually fixed after young adulthood and questions to respondents about education have relatively low nonresponse rates and are not complex; for these reasons, education is the most widely used measure of SES in

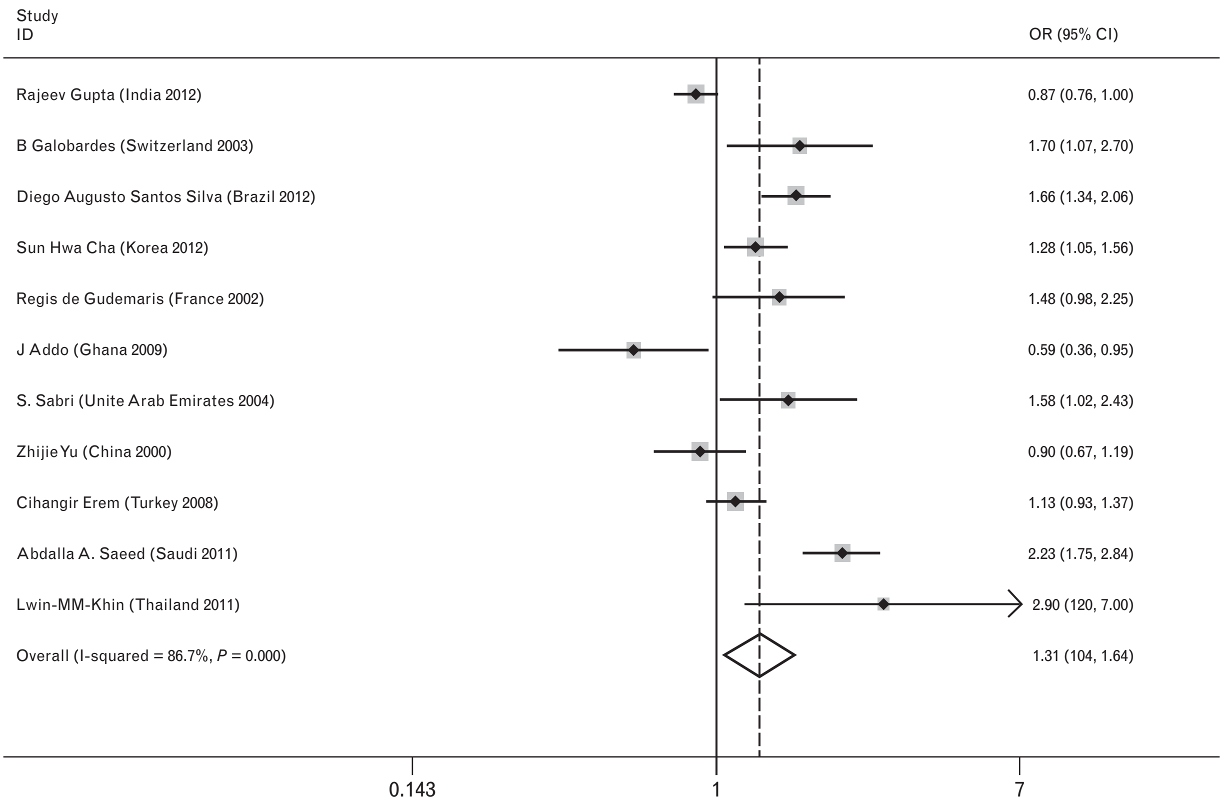

FIGURE 3 Forest plot of occupation categories and risk of hypertension prevalence. OR and 95% CI for hypertension prevalence and occupational categories (the lowest vs. the highest socioeconomic status category) in individual studies and for all studies combined. OR from the individual studies are indicated by squares and the size of the square represents the statistical weight that each study contributed to the random effect summary estimate. Horizontal lines indicate the study-specific 95% CI. Diamond represents the overall summary RR and its 95% CI. CI, confidence interval; OR, odds ratio.

epidemiologic studies [57]. Many studies have shown that the prevalence of hypertension increases as the educational status decreases [58–60]. There are three interrelated pathways that could explain education likely confers health benefits. First, education level might strongly influence adherence through knowledge of hypertension and health behavior [33]. People with higher education levels had more of a chance to know about hypertension and subsequently have a healthier lifestyle [53], and they were more likely to exercise, to drink moderately, to receive preventive medical care, and were less likely to smoke [61], which could decrease or delay the occurrence of hypertension. Second, highly educated people often could improve their working conditions, healthcare and income. High prevalence of hypertension in the group with a low education level might result from the fact that the risk factors such as stress and working conditions were more common [62], they had difficulties in reaching healthcare services and had higher total costs [57]. In addition, the well educated have socio-psychological resources, including a high sense of personal control and social support, which has been proved as a protective factor for hypertension [58]. We focus on education as the aspect of SES which is most important to health – not to the exclusion of income and occupation, but as the variable that structures the other two, education is the key to one's position in the stratification system; it shapes the likelihood of being unemployed, the kind of job a person can get and income [61].

The present meta-analysis showed that women with a lower SES had a higher significant relationship with hypertension than their higher SES counterparts, whereas the result was not significant in men. This could be attributed to the fact that women have contact with healthcare systems more frequently [63], and they have substantially greater consultation rates across all illness categories and were more likely than men to consult if they had an illness episode [64]. Furthermore, women may be more interested in maintaining a good body through proper exercise, balanced diet and healthy lifestyle. Although men and women make very different uses of health service, women are more affected than men by financial barriers; when nonfinancial barriers and health status are controlled for, poorer women appear to be at risk for underutilization of physicians' services [65]. In other words, women in higher SES may be more exposed to health information and be more likely than men to modify their unhealthy lifestyles.

Between 1970 and the end of the 1990s, nutritional situation in many developing countries had radically changed [66]. Changes in the composition of diet followed the introduction of food processing and the fast-food industry, and diets had become richer in calories, salt, sugar and fat [67]. In developed countries, the highest energy-density foods are often the cheapest and diets which include foods with a high added sugar or fat content are more accessible to lower-income groups [68]. Meanwhile, in developing countries, owing to adoption of an

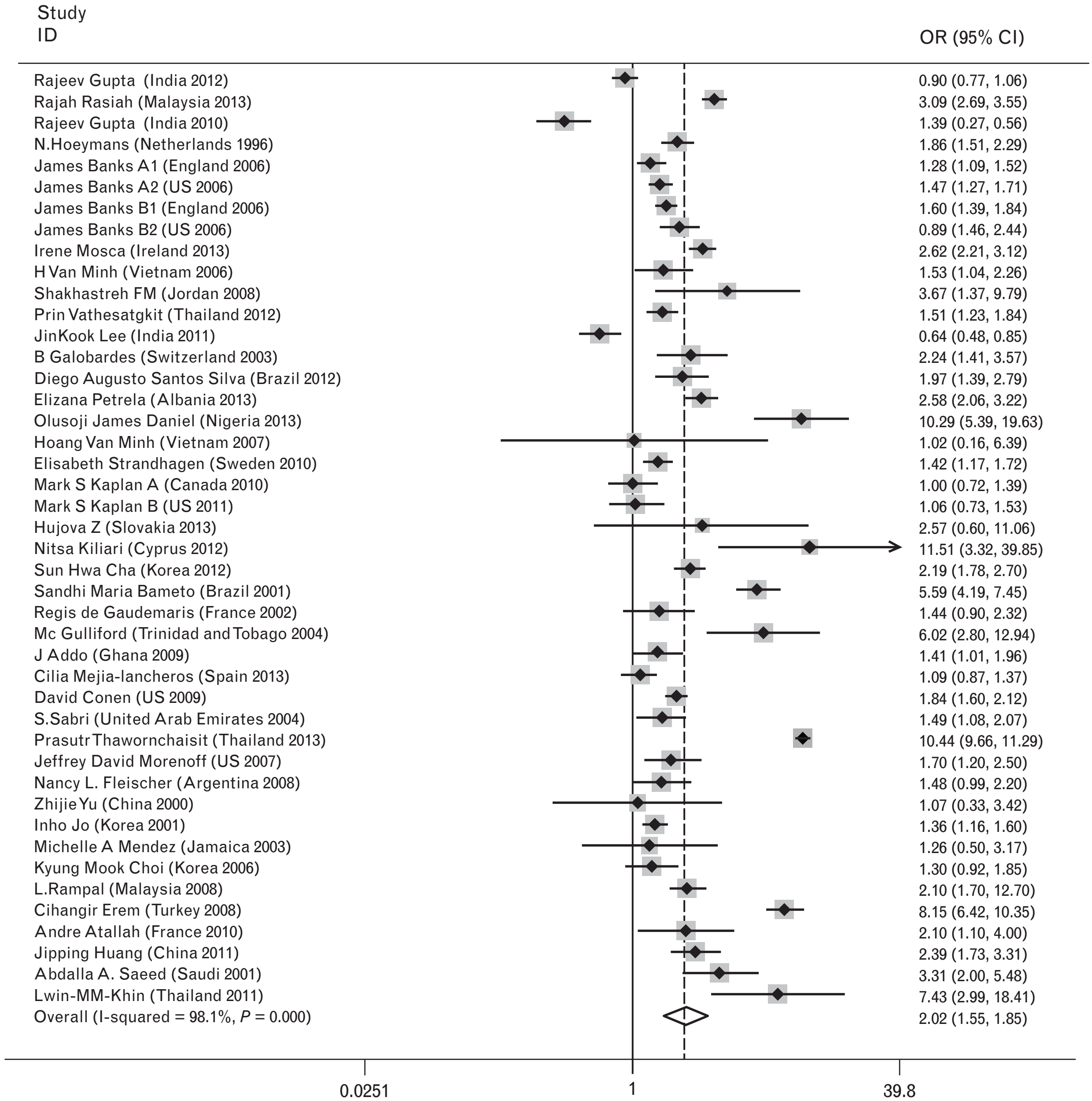

FIGURE 4 Forest plot of education categories and risk of hypertension prevalence. OR and 95% CI for hypertension prevalence and educational attainment (the lowest vs. the highest socioeconomic status category) in individual studies and for all studies combined. OR from the individual studies are indicated by squares and the size of the squares represents the statistical weight that each study contributed to the random-effect summary estimate. Horizontal lines indicate the study-specific 95% CI. Diamond represents the overall summary OR and its 95% CI. CI, confidence interval; OR, odds ratio.

increasingly western lifestyle, high-SES individuals seem to consume more fats, oils and animal-based foodstuff than their counterparts [69,70]; this diet change may negatively affect health, and could explain why the associations between low SES and hypertension were not significant in some low-income regions and countries.

In some previous studies, the prevalence of hypertension in blacks seemed higher than that in whites. However, this difference could not be entirely explained by racial factors. Actually, hypertension is mediated by factors normally found in association with lower SES, and blacks are overrepresented in lower SES groups [71], which could influence their knowledge, awareness, lifestyle and so on, resulting in increased prevalence of hypertension. A study by Agyemang *et al.* [72] indicated that substantial differences in the prevalence of hypertension between people of African and European origin are greatly reduced after adjustment for SES.

Several limitations of our study must be noted when interpreting these findings. Because of differences in the definition and classification of SES across studies, to overcome the problem and to increase comparability across the studies, we chose the extreme categories – the highest and the lowest SES strata – for comparison, that could impair the possibility of studying the social gradient and could be considered as a limitation of the analysis.

TABLE 1. Pooled estimates for the lowest vs. the highest socioeconomic category and prevalence of hypertension in series of subgroup analyses (measured using odds ratios)

Subgroup analysis	*n*	Income (95% CI)	Q *P* value	I^2 (%)	*n*	Occupation (95% CI)	Q *P* value	I^2 (%)	*n*	Education (95% CI)	Q *P* value	I^2 (%)
Summary pooled estimate	32	1.19 (0.96 to 1.48)	<0.001	96.6	11	1.31 (1.04 to 1.64)	<0.001	86.7	44	2.02 (1.55 to 2.63)	<0.001	98.1
Region												
USA/Canada	7	1.45 (1.25 to 1.69)	<0.001	76.7	0	–			6	1.49 (1.23 to 1.80)	0.002	74.3
Europe	3	1.28 (0.87 to 1.87)	<0.001	89.7	2	1.58 (1.16 to 2.15)	0.663	0.0	12	1.82 (1.48 to 2.24)	<0.001	86.1
Asia	14	1.07 (0.68 to 1.69)	<0.001	97.8	7	1.32 (0.99 to 1.74)	<0.001	88.8	19	1.99 (1.19 to 3.31)	<0.001	98.9
Latin America	5	1.48 (1.18 to 1.84)	0.043	59.3	1	1.66 (1.34 to 2.06)	–		3	2.56 (1.11 to 5.89)	<0.001	94.4
Africa	3	0.77 (0.38 to 1.55)	0.042	68.4	1	0.59 (0.36 to 0.95)	–		4	3.24 (1.09 to 9.62)	<0.001	91.9
Country's income												
High	16	1.36 (1.16 to 1.59)	<0.001	88.6	5	1.63 (1.27 to 2.09)	0.016	67.0	23	1.69 (1.49 to 1.91)	<0.001	81.3
Middle/low	16	1.04 (0.67 to 1.60)	<0.001	97.5	6	1.08 (0.81 to 1.44)	<0.001	86.3	21	2.23 (1.37 to 3.62)	<0.001	98.7
Sex												
Male	11	0.99 (0.54 to 1.79)	<0.001	97.1	2	1.04 (0.78 to 1.40)	0.157	50.2	14	1.25 (0.99 to 1.58)	<0.001	90.4
Female	9	1.58 (0.89 to 2.82)	<0.001	95.3	2	1.38 (0.69 to 2.77)	0.026	79.7	17	2.23 (1.56 to 3.21)	<0.001	95.3
Mean age (years)												
<40	5	0.72 (0.76 to 1.45)	<0.001	98.2	3	1.81 (1.43 to 2.29)	0.117	53.4	10	2.65 (1.27 to 5.55)	<0.001	98.6
40–50	12	1.23 (0.99 to 1.53)	<0.001	82.0	5	0.97 (0.78 to 1.21)	0.007	71.3	15	1.76 (1.27 to 2.44)	<0.001	94.4
>50	11	1.33 (1.10 to 1.61)	<0.001	89.7	3	1.57 (1.09 to 2.26)	0.131	50.7	15	1.73 (1.38 to 2.16)	<0.001	93.5
Adjustment strategy												
Adjusted for hypertension risk factors	3	1.28 (1.04 to 1.58)	0.455	0.0	3	1.163 (0.83 to 1.63)	0.107	55.3	6	1.73 (1.39 to 2.14)	0.220	28.6
Unadjusted for hypertension risk factors	29	1.18 (0.93 to 1.49)	<0.001	97.0	8	1.31 (0.98 to 1.75)	<0.001	88.5	38	2.09 (1.55 to 2.64)	<0.001	98.4
Design												
Cohort	11	1.10 (0.73 to 1.67)	<0.001	98.7	2	1.58 (1.16 to 2.15)	0.663	0.0	14	1.90 (1.12 to 3.22)	<0.001	99.2
Cross-sectional	20	1.27 (1.05 to 1.54)	<0.001	84.3	7	1.16 (0.88 to 1.54)	<0.001	90.9	28	2.00 (1.56 to 2.57)	<0.001	94.1
Case-control	1	0.99 (0.64 to 1.51)	–		2	1.89 (1.10 to 3.24)	0.224	86.7	2	3.14 (0.66 to 15.08)	0.01	90.6
Sample size												
<1000	6	0.90 (0.47 to 1.72)	<0.001	99.3	1	1.48 (0.98 to 2.25)	–		6	2.65 (1.22 to 5.80)	<0.001	99.3
1000–10000	21	1.37 (1.17 to 1.59)	<0.001	85.0	7	1.16 (0.88 to 1.54)	<0.001	90.9	28	1.63 (1.33 to 2.00)	<0.001	94.6
>10000	5	0.89 (0.59 to 1.32)	0.130	43.7	3	1.75 (1.30 to 2.35)	0.474	0.0	10	3.34 (1.95 to 5.73)	<0.001	87.1

CI, confidence interval; *n*, number of studies.

TABLE 2. Pooled estimates for the lowest vs. the highest socioeconomic category and prevalence of hypertension by raw data (measured using odds ratios and rate differences)

	n	OR (95% CI)	Q *P* value	I^2 (%)	RD (95% CI) per 100 participants	Q *P* value	I^2 (%)
Income	24	1.18 (0.88 to 1.59)	<0.001	97.4	5.2 (1.4 to 9.0)	<0.001	96.9
Occupation	7	1.26 (0.95 to 1.68)	<0.001	90.8	4.9 (−1.0 to 10.8)	<0.001	89.9
Education	32	2.15 (1.56 to 2.97)	<0.001	98.6	13.4 (10.2 to 16.6)	<0.001	97.4

CI, confidence interval; *n*, number of studies; OR, odds ratio.

Except age, no other study-level characteristics for any of the SES indicators were found significant in our meta-regression analyses. This limitation was unavoidable since we had no access to primary data, which would lead unidentified study-level factors not be observed and the results be exaggerated or narrowed.

Publication bias is a concern in meta-analysis which might lead to overestimation of the OR. Our meta-analysis was restricted to English-speaking peer-reviewed publications; so our estimates may have been affected by missing data from the studies performed in the low or middle-income countries where SES may be differently associated with hypertension, and it may explain the presence of publication bias detected in our analysis for combined estimates for studies on educational SES.

Our meta-analysis supports that low SES is associated with higher blood pressure, and this association is particularly evident in the level of education. Further research is required to identify and monitor hypertension to reduce the risk of this disease among the most vulnerable groups in different countries and among different societies.

ACKNOWLEDGEMENTS

The authors express their gratitude to Epidemiology, Public Health and Management Department, Chongqing Medical University.

Conflicts of interest

There are no conflicts of interest.

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Reviewers' Summary Evaluations

Reviewer 1

This meta-analysis is focused on a topic on which the literature is scanty. The appropriate statistical methodology is a strength of this study. The main limitation is that the authors did not have access to the raw data of all clinical studies and therefore relied on previously published odds-ratios.

Reviewer 2

Strength: The paper provide a significant evidence of an association between hypertension and socioeconomic status.

Weaknesses: No information on frequency and type of hypertension risk.