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**Prevalence, awareness and control of hypertension in Malaysia from 1980-2018: A systematic review and meta-analysis**

Soo MJ *et al*. Prevalence, awareness and control of hypertension in Malaysia

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**Abstract**

BACKGROUND

Hypertension is a common public health problem worldwide and is a well-known risk factor for increased risk of cardiovascular diseases, contributing to high morbidity and mortality. However, there has been no systematic review and meta-analysis of a multiethnic population such as that of Malaysia.

AIM

To determine the trend in prevalence, awareness and control rate of hypertension in Malaysia.

METHODS

Systematic searches were conducted in six databases (PubMed, Scopus, Ovid, CINAHL, Malaysian Medical Repository and Malaysia Citation Index) for articles published between 1980 and 2018. Two authors reviewed the studies and performed quality assessment and data extraction independently. Pooled estimates of hypertension prevalence, awareness and control rate were calculated using the DerSimonian-Laird random-effects model. Subgroup and sensitivity analyses were performed.

RESULTS

We included 56 studies involving a total of 241796 participants. The overall pooled prevalence of hypertension aged ≥ 18 years was 29.7%. The prevalence of hypertension was the lowest in the 1980s (16.2%, 95% confidence interval (CI): 13.4, 19.0), increasing up to 36.8% (95%CI: 6.1, 67.5) in the 1990s, then decreasing to 28.7% (95%CI: 21.7, 35.8) in the 2000s and 26.8% (95%CI: 21.3, 32.3) in the 2010s. The prevalence of awareness was 51.4% (95%CI: 46.6, 56.3), while 33.3% (95%CI: 28.4, 38.2) of those on treatment had achieved control of their blood pressure.

CONCLUSION

In Malaysia, three in ten adults aged ≥ 18 years have hypertension, while four in ten adults aged ≥ 30 years have hypertension. Five out of ten people are aware of their hypertension status and only one-third of those under treatment achieved control of their hypertension. Concerted efforts by policymakers and healthcare professionals to improve awareness and control of hypertension should be of high priority.

**Key Words:** Prevalence; Awareness; Control; Hypertension; Blood pressure; Malaysia; Systematic review; Meta-analysis

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**Core Tip:** This is a systematic review and meta-analysis reporting that the pooled prevalence of hypertension in people aged ≥ 18 years in Malaysia was 29.7%. The pooled prevalence of awareness towards hypertension was 51.4 % and blood pressure control rate was 33.3%.

**INTRODUCTION**

Hypertension is a common public health problem over the past several decades[1,2]. It is one of the major risk factors for cardiovascular diseases such as stroke, heart failure and ischemic heart disease[3]. In Malaysia, trend analyses have been conducted based on the National Health and Morbidity Surveys, which are nationwide studies that have been performed every 10 years since 1986. The analyses have also shown the trend of hypertension in different genders and ethnicities[4-7]. Besides the National Health and Morbidity Surveys, several other studies have examined the prevalence, awareness and control of hypertension that differed from that of the National Health and Morbidity Surveys[8,9]. The prevalence in different settings and in different age groups may present a slightly different picture along with their accompanying set of problems.

The present systematic review aimed to determine the pooled prevalence of hypertension, awareness and control of hypertension in Malaysia from 1980 to 2018 based on a nationwide survey and other important studies that reported the prevalence of hypertension in different settings and specific groups. Heterogeneities among cross-sectional studies and the national survey may conceivably cause different rates of prevalence. Hence, there is a need for a systematic review and meta-analysis to estimate the pooled prevalence of hypertension in Malaysia. We are not only reporting the trend of hypertension prevalence in Malaysia from 1980 to 2018 but are also providing some important insights into the awareness and control of hypertension among Malaysians.

**MATERIALS AND METHODS**

***Protocol registration***

The present review was registered with PROSPERO (2018: CRD42018075369) and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines[10].

***Data sources***

We searched six databases (PubMed, Ovid, Scopus, CINAHL, Malaysian Medical Repository and Malaysia Citation Index) for the relevant articles and included all relevant citations published before 28 February 2018.

***Search strategy***

Theliterature search used the following search terms: (prevalence) and (awareness) and (control) and (hypertension or high blood pressure) and (Malaysia), and a combination of expanded MeSH terms and free-text searches were used for the final search up to 28 February, 2018: (Prevalence OR Aware\* OR Unaware\* OR Undiagnosed OR Control\* OR Uncontrol\* OR ‘Achieved target’) AND (Hypertension OR ‘Blood pressure’ OR ‘Systolic blood pressure’ OR ‘Diastolic blood pressure’ OR ‘Raised blood pressure’ OR ‘High blood pressure’) AND (Malaysia OR Perlis OR Kedah OR Penang OR ‘Pulau Pinang’ OR Perak OR Johor OR Selangor OR Pahang OR Malacca OR Melaka OR Terengganu OR Kelantan OR ‘Negeri Sembilan’ OR Sabah OR Sarawak OR ‘Wilayah Persekutuan’ OR Putrajaya OR ‘Kuala Lumpur’ OR ‘Labuan’).

***Eligibility criteria***

Any studies, reports or articles published between 1 January, 1980 and 28 February, 2018 and fulfilling the following criteria were included in the analysis: (1) included the general population aged ≥ 18 years; (2) studied the prevalence of hypertension diagnosed using digital automated or mercury sphygmomanometers; (3) studied either the prevalence, awareness and control of blood pressure (BP) or hypertension individually or any combination of the three; and (4) in English only. We excluded intervention studies, case studies, pharmacogenetic studies, case series, qualitative data, comments or letters, audits, narrative reviews, conference proceeding, opinion pieces, methodological, editorials, animal studies or any other publications lacking primary data and/or explicit method descriptions. When several publications were derived from the same dataset or cohorts, the article that provided the most updated data was selected. We identified other pertinent studies through reverse–forward citation tracking of relevant articles.

***Selection process***

We imported relevant articles identified through the databases into EndNote X5 and removed duplicate publications. Two authors (Chow ZY and Tan CH) screened the titles and abstracts independently to search for eligible articles based on the inclusion criteria. If there were discrepancies on including studies, discussions were held and resolved by the senior authors (Ching SM, Hoo FK, Devaraj NK, Salim HS and Cheong AT) for final consensus before the full text of each relevant article was reviewed.

***Data collection***

One author (Ramachandran V) recorded data from the selected studies into the extraction form using Excel, while the second author (Ching SM) verified the accuracy and completeness of the extracted data.

***Data items***

The following characteristics of the selected studies were extracted: first author, year of publication, study setting, study design, location of study, geographical area (rural or urban), BP apparatus, sample size and cases with hypertension. The outcome measures extracted were the prevalence of hypertension in terms of the difference of proportion/percent of hypertension, awareness and control in the total patients examined.

***Summary measures***

Hypertension was defined as BP ≥ 140/90 mmHg based on guidelines from the Fifth Joint National Committee. Awareness was defined as knowing one’s own hypertension status or having been diagnosed with hypertension previously. Control was defined as achieving a target BP of < 140/90 mmHg[11].

***Risk of assessment based on the critical appraisal checklist***

Each article underwent quality assessment by two authors (Soo MJ and Lee KW) using a modified critical appraisal checklist (Supplementary material Appendix 1)[8]. The checklist consisted of 11 items that assessed the components in observational studies. Whenever the information provided was insufficient to assist in the evaluation of a certain item, the two authors agreed to grade that item as ‘0’ indicating absence of the item, ‘0.5’ indicated that the information was incomplete, and ‘1’ indicated that the item was presented clearly. The quality of each article was graded as high if it scored ≥ 7/11, or low if it scored < 7/11[8]. The results of the quality assessment are shown in supplementary material Appendix 2.

***Data synthesis***

The results from the meta-analysis summarized the data narrative and statistically used a tabulated format. Heterogeneity between studies for the pooled estimates was examined using *I*2 (*I*2 < 25%, low; *I*2 = 25%-30%, moderate; *I*2 > 50%, high), indicating the percent of total discrepancy due to variation in the studies[12].

***Statistical analysis***

We used OpenMeta[Analyst] for data analysis (http://www.cebm.brown.edu/openmeta/index.html)[13]. The prevalence estimated from individual studies was pooled using random-effects (DerSimonian-Laird method) meta-analysis and was reported with 95% confidence interval (CI). Subgroup analysis was performed to examine the prevalence, awareness and control of hypertension by age group, sex, ethnicity, study setting, study design, geographical origin and BP tools.

***Additional analysis***

Publication bias was assessed by sensitivity analysis using the leave-one-out analysis. We also performed sensitivity analyses for the prevalence of hypertension by discarding low-quality studies, removing outlier subpopulations (point estimates > ± 3 standard deviations)[14] or removing smaller subpopulations (size < 100) or large sample sizes (size > 5000)[15], where these publication biases are known to have effects on the estimated prevalence. The effect size of interest was the proportion of individuals with hypertension. The secular trend of prevalence was estimated by calculating the point estimates for four separate decades.

**RESULTS**

***Description of included studies***

We identified 1493 manuscripts in the initial search (Figure 1). After removal of duplicate records (*n* = 251), 1242 studies were retrieved for further assessment. After careful evaluation of the inclusion/exclusion criteria, 52 studies fulfilled our criteria, and this together with another four studies identified from cross-referencing, a total of 56 studies were included in our meta-analysis.

***Characteristics of the included studies***

The main characteristics of the included studies are shown in Table 1[16-71] and supplementary material Appendix 3 in encompassing the prevalence, awareness and control of hypertension of the included studies. A total sample size of 241796 respondents from Malaysia was included in the analysis. Overall, the ethnicity distribution was 56.5% Malay, 24.2% Chinese, 9.7% Indian and 9.5% other ethnicities. Fifty-one studies were conducted in the community setting, four were in a hospital setting and one was in a primary care clinic. Quality assessment using a modified critical appraisal checklist showed that the majority of the studies (52/56) were of good quality with only four having poor quality.

***Prevalence of hypertension: Overall and subgroup analysis***

Table 2 shows the prevalence of hypertension in Malaysia is 29.7% (95%CI: 26.1, 33.3) (Figure 2). The prevalence of hypertension for those aged ≥ 30 years was 40.0% (Figure 3). The pooled prevalence of hypertension increased with age as the prevalence was 8.6% in adults aged 18–29 years as compared to 42.8% in adults aged ≥ 60 years (Figure 4).

Among adults aged ≥ 18 years, the prevalence of hypertension was higher in men compared to women (31.4%, 95%CI: 26.5, 36.2 *vs* 27.8%, 95%CI: 20.7, 34.9) (Figure 5A and 5B). The prevalence of hypertension was highest among Malays (37.3%, 95%CI: 32.9, 41.7), followed by Chinese (36.4%, 95%CI: 31.6, 41.2) and Indians (34.8%, 95%CI: 31.2, 38.4) (Figure 6A-D). The prevalence of hypertension was 24.3% in healthcare setting as compared to 30.2% in community setting (Figure 7). The prevalence of hypertension in rural areas was 35.6% as compared to 25.4% in urban areas (Figure 8A and 8B).

The prevalence of hypertension was 16.2% in the first decade (1980–1989), 36.8% in the second decade (1990–1999), 28.7% in the third decade (2000–2009) and 26.8% in the fourth decade (2010–2018) (Figure 9).

The prevalence of hypertension in studies that used mercury sphygmomanometers was 33.2% (95%CI: 26.4, 40.0) as compared to 30.8% (95%CI: 25.5, 36.0) in those studies that used a digital BP device (Figure 10). Sensitivity analysis showed that all studies affected the pooled prevalence of hypertension causing it to vary from 25.6% to 30.2%. Therefore, we did not eliminate any studies from the analysis.

***Prevalence of awareness towards hypertension***

The overall prevalence of awareness towards hypertension in Malaysia was 51.4% (95%CI: 46.6, 56.3) (Table 3 and Figure 11). The prevalence of awareness towards hypertension among male hypertensive patients was 67.8% (Figure 12A), whereas it was 62.7% (Figure 12B) among female hypertensive patients[52,56]. Hypertension awareness among the Malays was 45.4% (Figure 13A), while that among non-Malay was 47.9% (Figure 13B). The prevalence of awareness towards hypertension among hypertensive patients living in rural areas was 45.3% (Figure 14) as compared to 54.1% in urban areas (Table 3).

***Prevalence of control rate in hypertension***

The control rate of hypertension was indicated in Table 3. Among the patients who were aware they were hypertensive, 33.3% (95%CI: 28.4, 38.2) achieved control of their BP (Figure 15). Our analysis found that men had slightly better control than women (37.1% *vs* 30.4%) (Figure 16A and 16B). We also found that 29.3% of Malays had control of their BP (Figure 17A), while that of non-Malays was 35.6% (Figure 17B). Urbanites had higher hypertension control than those living in rural areas (36.5% *vs* 34.1%) (Figure 18) (Table 3).

***Sensitivity analyses***

Visual inspection of the funnel plot of the result of overall prevalence of hypertension showed an asymmetrical plot, suggesting some degree of publication bias (Figure 19). The main analysis for the prevalence of hypertension was rerun by removing one subpopulation at a time. The pooled estimates did not vary much from the original analysis during each removal. The removal of five low-quality studies or smaller subpopulations (size < 100) also did not affect the original estimate of hypertension rates (Table 4).

**DISCUSSION**

To the best of our knowledge, this systematic review is the first in Malaysia to describe the prevalence and its trends over four decades for hypertension awareness and control. In addition, due to the fact that Malaysia is a multiethnic country, its variation in the prevalence, awareness and control of hypertension is crucial for us to examine in order to plan our policy in managing hypertension on a nationwide scale.

***Prevalence***

The overall pooled prevalence of hypertension in Malaysia was 29.7%. The overall prevalence of hypertension in Malaysia was within the range of worldwide hypertension prevalence (20%–50%), as described in a systematic review by Kearney *et al*[[72](#_ENREF_72)]. Malaysia has a higher prevalence of hypertension as compared to Thailand (24.7%), Singapore (23.5%) and China (25.2%)[73-75]. A review showed that this prevalence is as high as that in developed countries despite Malaysia being a developing country[76]. In fact, the prevalence of hypertension in Malaysia is higher than that of the United States by 0.7%[77].

***Trend of hypertension***

We noticed a low prevalence of hypertension in the 1980s. This could be due to only having one study that reported the prevalence of hypertension in the 1980s. Furthermore, that study involved the Kadazan and Bajau ethnic groups, which are minority groups in a rural part of Sabah[32]. Hence, it is not surprising that the prevalence was so low. The possible explanations include the fact that the study was not only limited to a rural population, but it was also the era before urbanization whereby unhealthy lifestyles were not practiced commonly reflected strongly by a low prevalence of diabetes of less than 5% in the years 1980-1985 in South East Asia[78]. Otherwise, we noticed a spike in hypertension prevalence from the 1980s to the 1990s (36.8%). Then, it decreased to 28.7% in the 2000s and further decreased to 26.8% in the 2000s. A possible reason for the increased prevalence in the 1990s could be due to the fact that among the 30 studies that specified their study period, only two studies were conducted in the 1990s. One study, which reported hypertension prevalence of 21.1%, involved three rural communities in Bagan Datoh involving a wide variation of citizens from different age groups[56], whereas the other study involved three semi-rural areas in Kuala Langat where the study respondents were from the older age groups (range, 55–95 years; mean age, 65.4 years)[29]. This significantly increases the overall pooled prevalence of hypertension if we only take these two studies with their extreme ends of prevalence into account. In comparison to the trend of prevalence of hypertension in other countries, United States was one of the countries with a consistent prevalence of hypertension of around 29% according to the United States’ National Health and Nutrition Examination Survey[77].

***Age and hypertension***

Epidemiological studies have shown that the prevalence of hypertension increases with age, which is consistent with our review. Importantly, we also found that hypertension prevalence was doubled in those aged 40–49 years (27.9%) from those aged 30–39 years (13.5%). Comparing our results to that of a developed country, we also found a similar doubling phenomenon in hypertension prevalence, but it only happened in the older age group, which was 63.1% in those aged ≥ 60 years, rising from 33.2% from those aged 40–59 years[77]. It is expected that aging is closely related to increased rates of hypertension because of the arterial structure alteration and ongoing calcification that leads to increased arterial stiffness[79]. However, when focusing on the older population aged ≥ 60 years, the prevalence of hypertension in this age group in Malaysia is the lowest among Asian countries such as Singapore (73.9%), Korea (68.7%), India and Bangladesh (65%), Taiwan (60.4%), Thailand (51.5%) and China (48.8%)[80-85]. However, this could be due to the fact that studies in Malaysia have defined the elderly as people aged ≥ 60 years old compared to the other studies above, which defined the elderly as people aged ≥ 65 years[80,81,83,85]. In Malaysia, the prevalence of hypertension was 8.6% among those aged 18–29 years and 13.5% among those aged 30–39 years. The prevalence rates are fairly similar to China (18–29 year age group, 9.6%; 30–39 year age group, 13.1%)[86] but lower compared to India (18–29 year age group, 13%; 30–39 year age group, 23%)[87].

***Gender and hypertension***

We found that the prevalence of hypertension was higher in men compared to women. This finding is similar to that of the National Health and Nutrition Examination Survey in the United States[88], which reported that regardless of race and ethnicity, men in the 20–40 year age group had higher prevalence of hypertension than women[88]. The sex differences in hypertension are due to both biological and behavioral factors[89]. Biologically, the female sex hormone, estrogen, serves as a protective factor against hypertension and other cardiovascular-related diseases in women[90,91]. Unhealthy lifestyle such as smoking was more prevalent among men compared to women[90-93]. Because smoking is a risk factor for hypertension[94,95], it is not surprising that the prevalence of hypertension is higher in men.

***Awareness***

In our review, 51.4% (95%CI: 46.6, 56.3) of the included sample was aware of their hypertension status. This finding is lower than the rates reported in United States (63%)[96], Singapore (69.7%)[80] and Korea (91.7%)[81]. Even though, the awareness of hypertension in Malaysia is higher than that in India (25.1%)[83] and Indonesia (35.8%)[73], this finding is still worrying as it indicates one out of two adults remain undetected or untreated for their hypertension. Therefore, various nationwide blood pressure screening campaign is urgently needed. Indeed May Measurement Month was a good move as it was a nationwide blood pressure screening program that was conducted in conjunction with World Hypertension Day under the tutelage of the International Society of Hypertension[94].

Regarding the higher prevalence of awareness towards hypertension in Malaysia as compared to India[83] and Indonesia[73], the possible explanation could be due to the fact that one of the studies was conducted in a residential home with a higher caregiver to resident ratio and frequent supervision. This explained why the residents’ awareness of hypertension was high[58]. On the other hand, another study involved university staff with high education levels, and therefore the awareness of hypertension will certainly be high[61]. In terms of ethnicity, only one study examined the ethnic differences of hypertension awareness[16], while the two other studies involved only Malay ethnicity as the study population[62] and Malay villagers in rural communities, respectively[70]. Comparison of geographical origin yielded similar results, where only one study examined the difference in awareness[16] while the three other studies all focused on awareness among the rural communities rather than examining the geographical difference of hypertensive awareness[46,52,62]. It will be right to assume that there will be much bias and higher heterogeneity, and therefore pooled analyses were not done for these subgroups.

***Control***

Hypertension control in Malaysia was 33.3%, which is much lower than that of developed countries such as the United States (53%)[17]. Conversely, it is higher than that of nearby countries such as China (13.8%)[73,84], Hong Kong (25.8%)[95] and the Philippines (27.0%)[97]. This could be due to the fact that Malaysia has been improving its quality of healthcare facilities, building more clinics and hospitals and more of the latest drugs are available in these healthcare facilities[98]. We found that men achieved better BP control than women. This is surprising because the literature reported that women are always more likely to have better health-seeking behavior and expected to have better blood pressure control[99]. Urban dwellers had better BP control, which correlates with a study in Southern China that reported similar results[100]. This may be due to limited access to healthcare facilities in rural areas despite the number of rural clinics increasing throughout the past four decades in Malaysia[98]. It seems likely that a poorer health awareness among those living in rural areas or with lower socioeconomic profiles remains an important barrier to visiting healthcare facilities and thereby receiving proper treatment.

***Strengths and limitations***

The strength of this review was the large sample size summarizing prevalence of hypertension in Malaysia across four decades. Furthermore, this is interesting to analyze the prevalence of hypertension according to different subgroups especially when Malaysia is known to have different races with corresponding different cultures and lifestyle. The accompanying underlying problems were different from each other, and it has been addressed in this systematic review.

However, there are several limitations. First, we found that many studies did not report data of prevalence, awareness and control of hypertension in subgroups of gender, ethnicity and geographical origin, whereby these factors could further help health care policy makers to configure hypertension screening and awareness campaigns according to these subgroups in regards to hypertension prevalence, poor awareness and lack of control. Secondly, we adopted strict inclusion and exclusion criteria and therefore unpublished data or grey literature were not included in the study. However, based on the sensitivity analysis, prevalence of hypertension after removal of these studies with poor quality, nonrandom sampling and/or extreme sample size were not changed as compared to overall pooled prevalence of hypertension. Thirdly, the estimates for the earlier time periods were based on fewer studies when compared to that for latter periods, which may have caused a paucity of literature on the topic of interest.

***Suggestion for future research***

Future studies on the prevalence of hypertension can address some of the issues noted in this research. The prevalence of hypertension according to gender, ethnicity and geographical origin should be studied in more detail. Nonrandom sampling method should be avoided because it would lead to bias in the conducted study. Besides that, future studies should also emphasize on adequate or larger sample size, which is more representative of a population.

**CONCLUSION**

One-third of Malaysian adults are hypertensive. The prevalence of hypertension is higher in people who reside in rural areas than in those who stay in urban areas. Slightly more than half of the adults are aware of their hypertension status and one-third of these patients achieved target BP control. In view of these findings, urgent steps for improving health promotion and health education need to be undertaken on a larger scale. Although our review shows a decreasing trend of hypertension prevalence throughout the past four decades, hypertension awareness and BP control among Malaysians have yet to improve significantly.

**ARTICLE HIGHLIGHTS**

***Research background***

Hypertension is a common public health problem worldwide.

***Research motivation***

Future studies on the prevalence of hypertension can address some of issues noted in this research. The prevalence of hypertension according to gender, ethnicity and geographical origin should be studied in more detail.

***Research objectives***

This systematic review aimed to determine the trend in prevalence, awareness and control rate of hypertension in Malaysia.

***Research methods***

A systematic search was conducted in six databases for articles published between 1980 and 2018. Authors reviewed the studies and performed quality assessment and data extraction independently.

***Research results***

The overall pooled prevalence of hypertension in Malaysia was 29.7%. The overall prevalence of awareness was 51.4%, and 33.3% of those on treatment had achieved control of their blood pressure.

***Research conclusions***

In Malaysia, three in ten adults aged ≥ 18 years have hypertension, while four in ten adults aged ≥ 30 years have hypertension. Five out of ten people are aware of their hypertension status and only one-third of those under treatment achieved control of their hypertension.

***Research perspectives***

Concerted efforts by policymakers and healthcare professionals to improve awareness and control of hypertension should be of high priority.

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**Footnotes**

**Conflict-of-interest statement:** The authors declare that they have no competing interests.

**PRISMA 2009 Checklist statement:** This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/Licenses/by-nc/4.0/

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Grade A (Excellent): 0

Grade B (Very good): 0

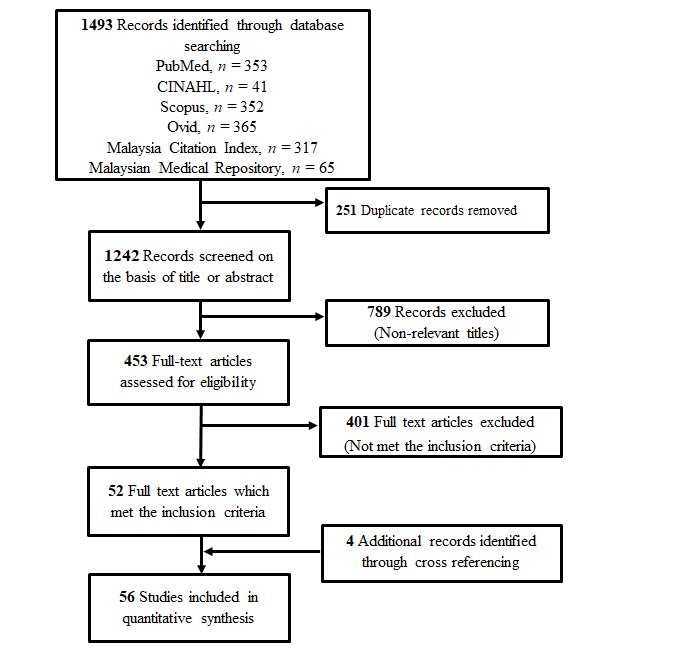
Grade C (Good): C, C

Grade D (Fair): D

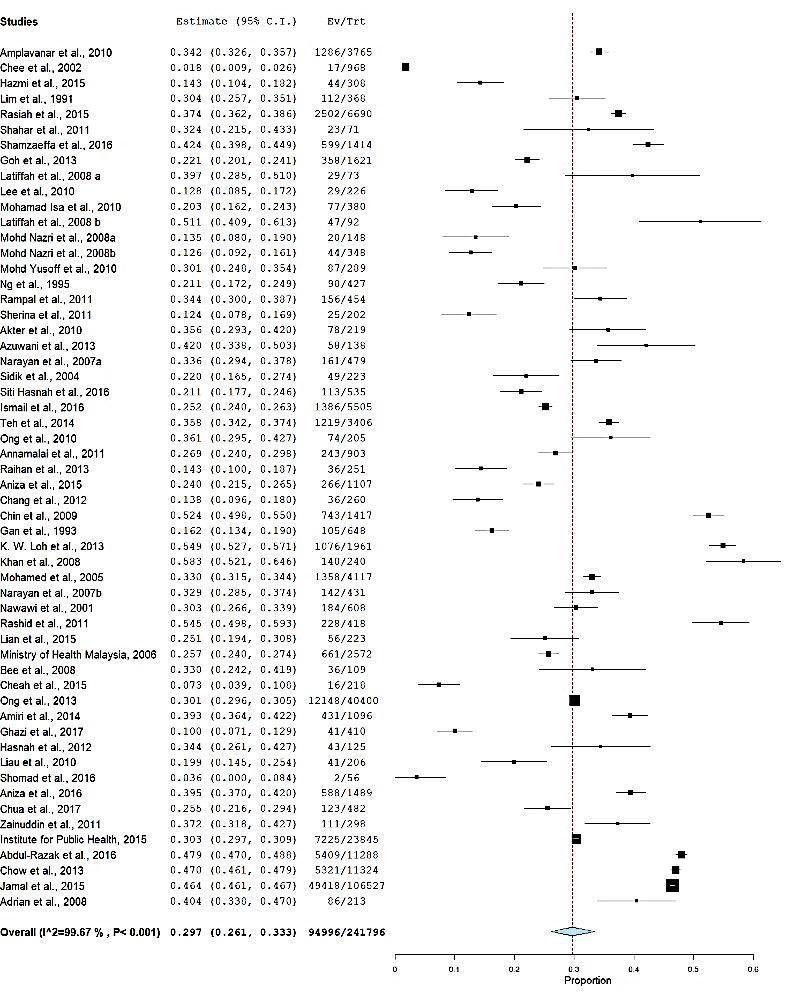
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**P-Reviewer:** Cheng TH, Tan X, Yang MS **S-Editor:** Wang JL **L-Editor:** Filipodia **P-Editor:** Li JH

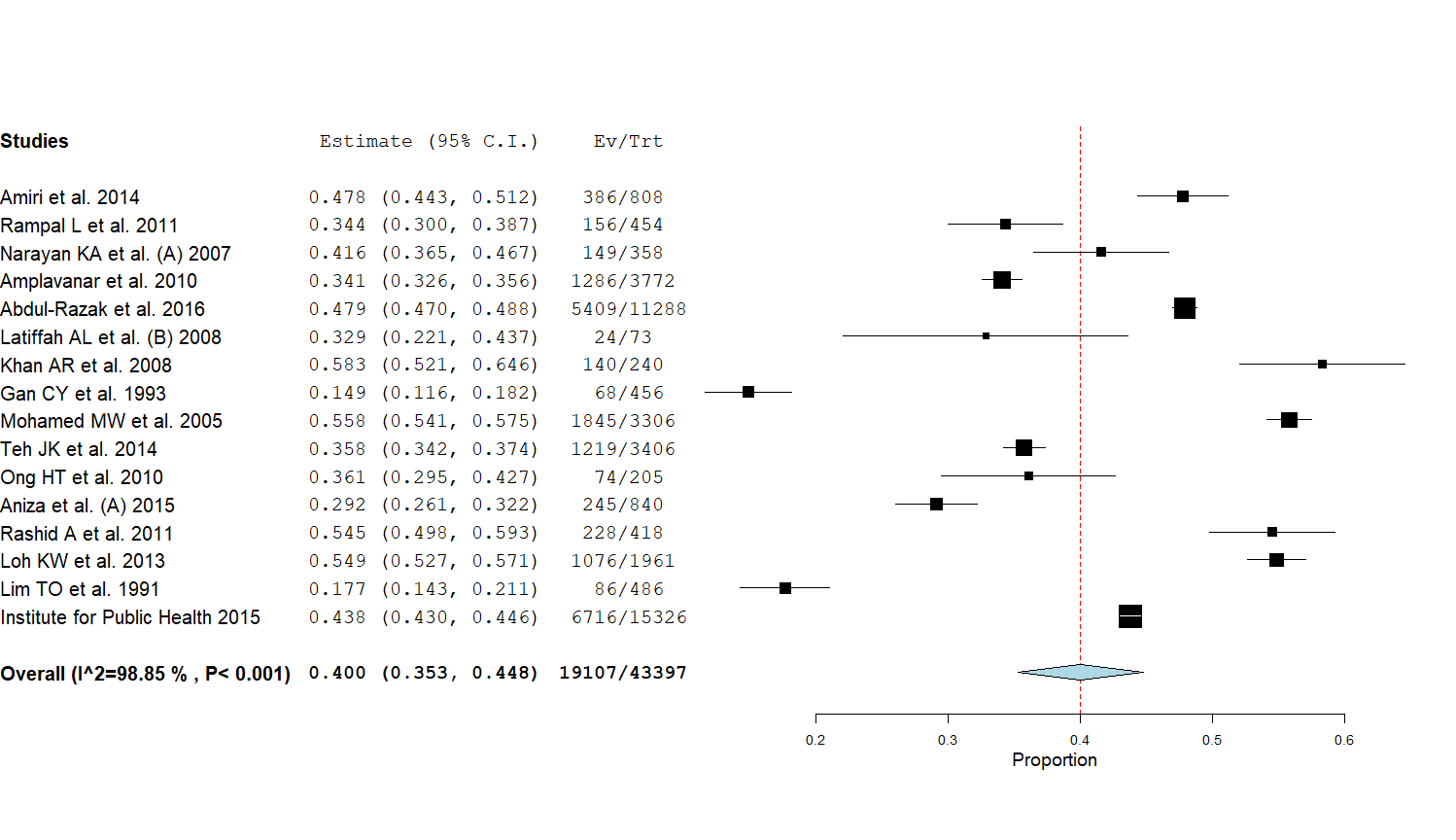
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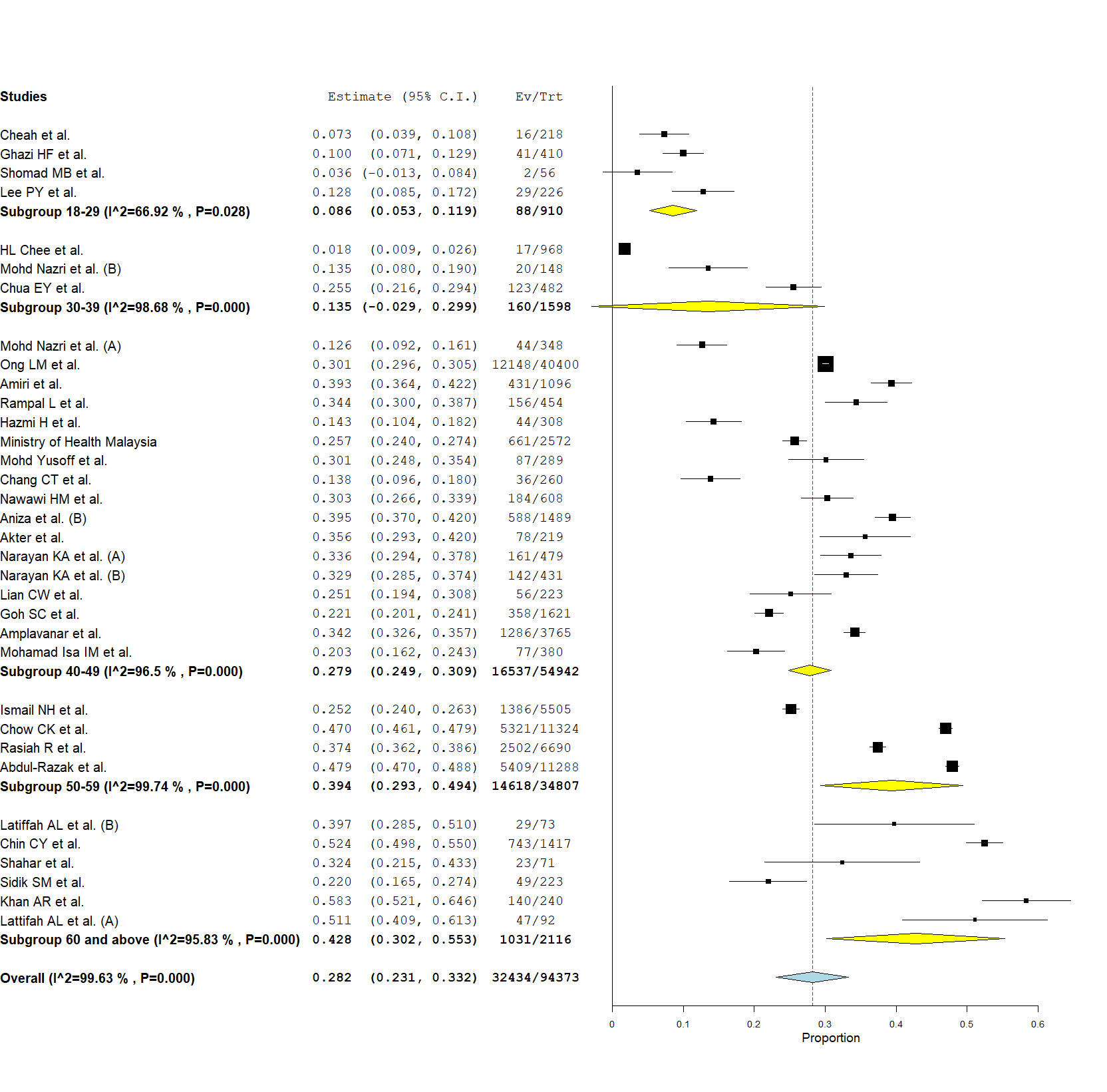
**Figure 1 Preferred reporting items for systematic review and meta-analysis flow diagram of the literature screening process.** Numbers indicate the article count retained at each step of the process.

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**Figure 2 Pooled prevalence of hypertension.**

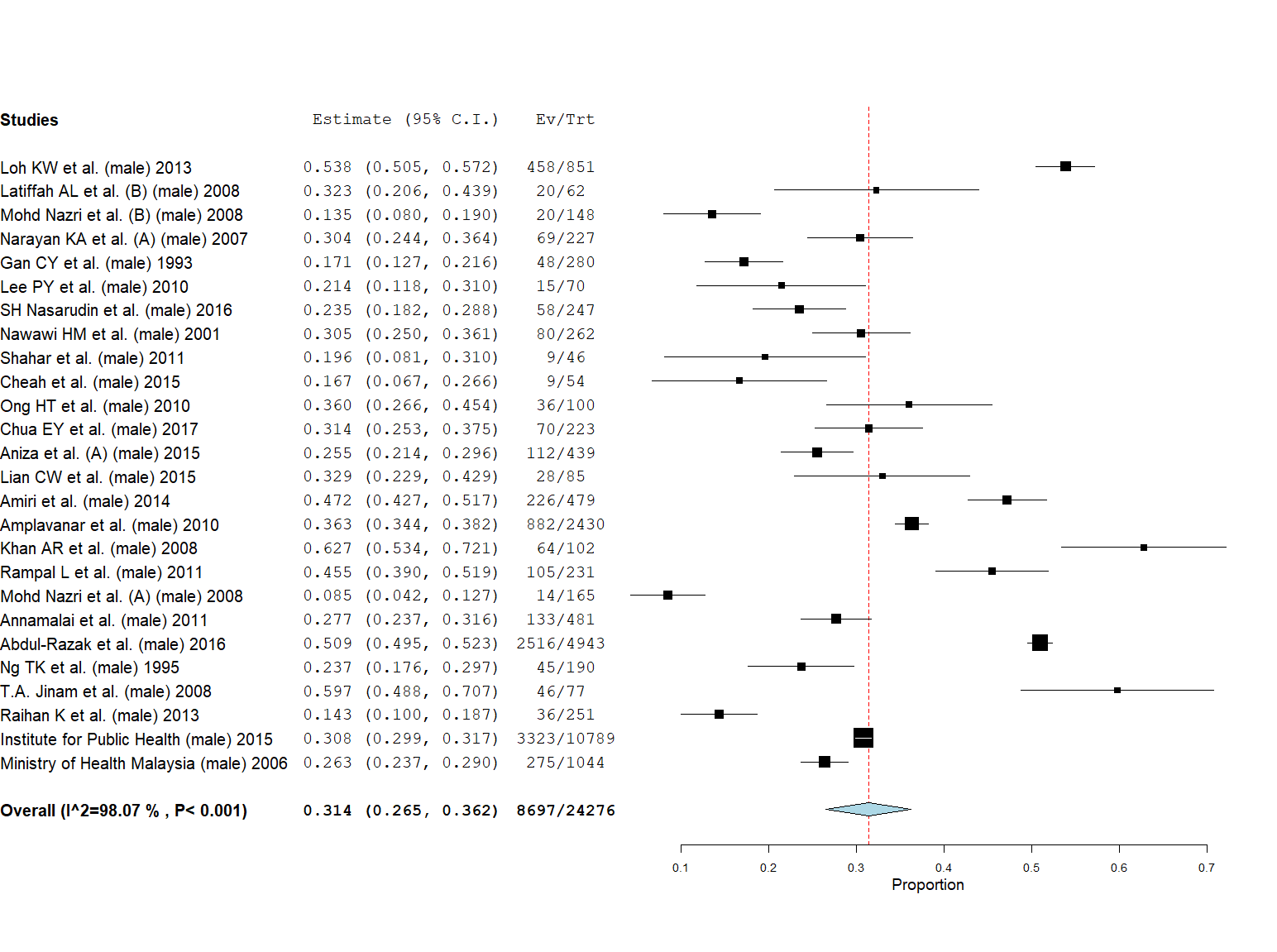
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**Figure 3 Pooled prevalence of hypertension in adults aged ≥ 30 years.**

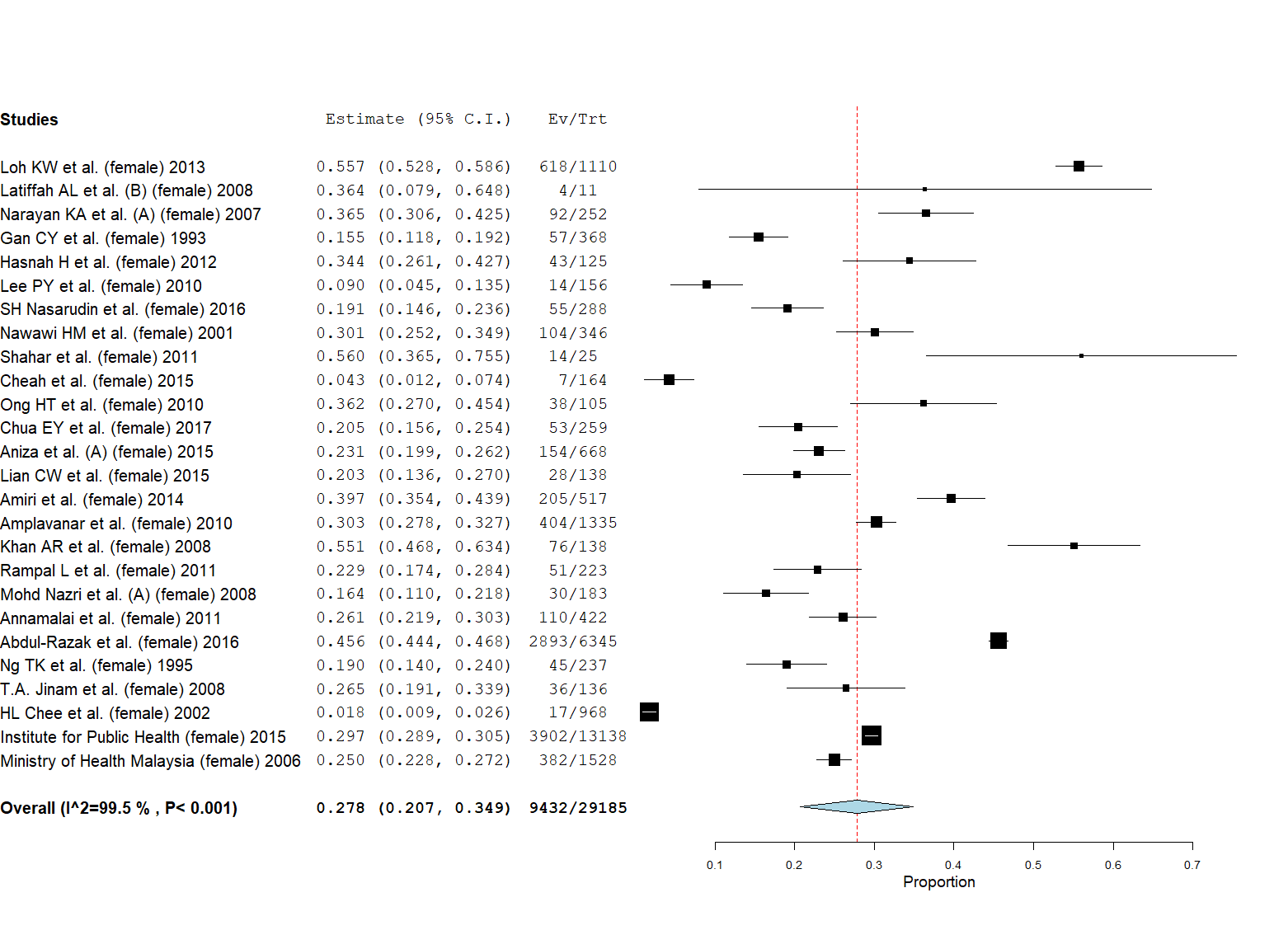
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**Figure 4 Pooled prevalence of hypertension subanalysis by age groups.**

**A**

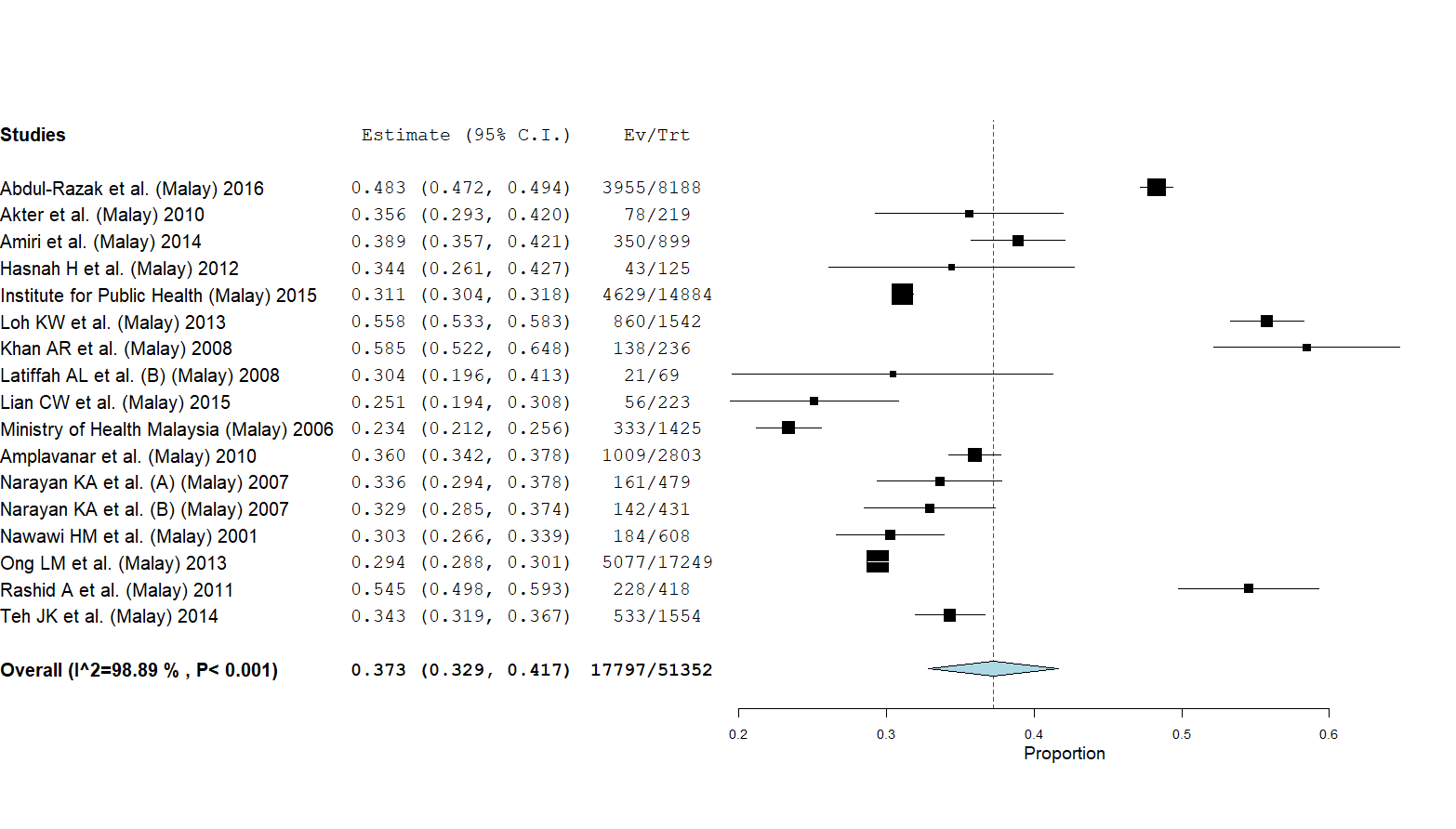
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**B**

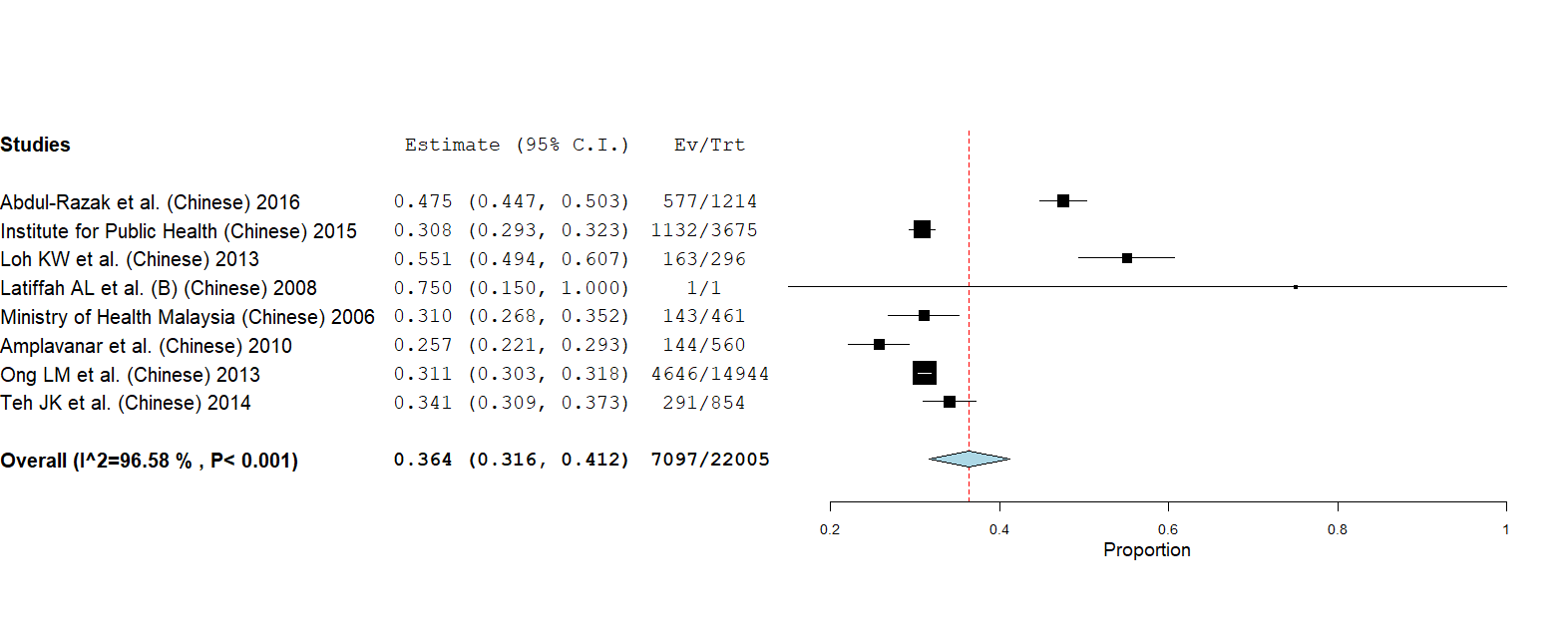
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**Figure 5 Pooled prevalence of hypertension in male and female adults.** A: In male adults; B: In female adults.

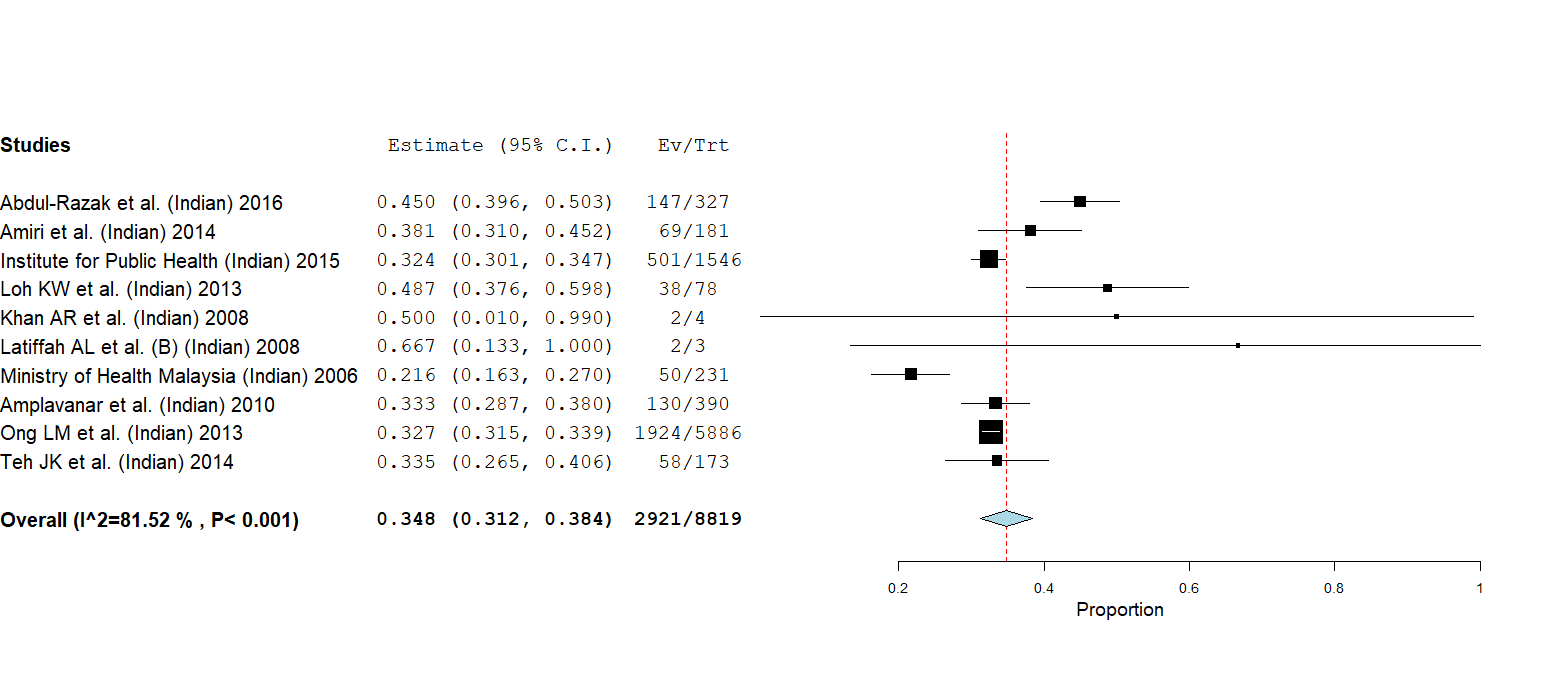
**A**

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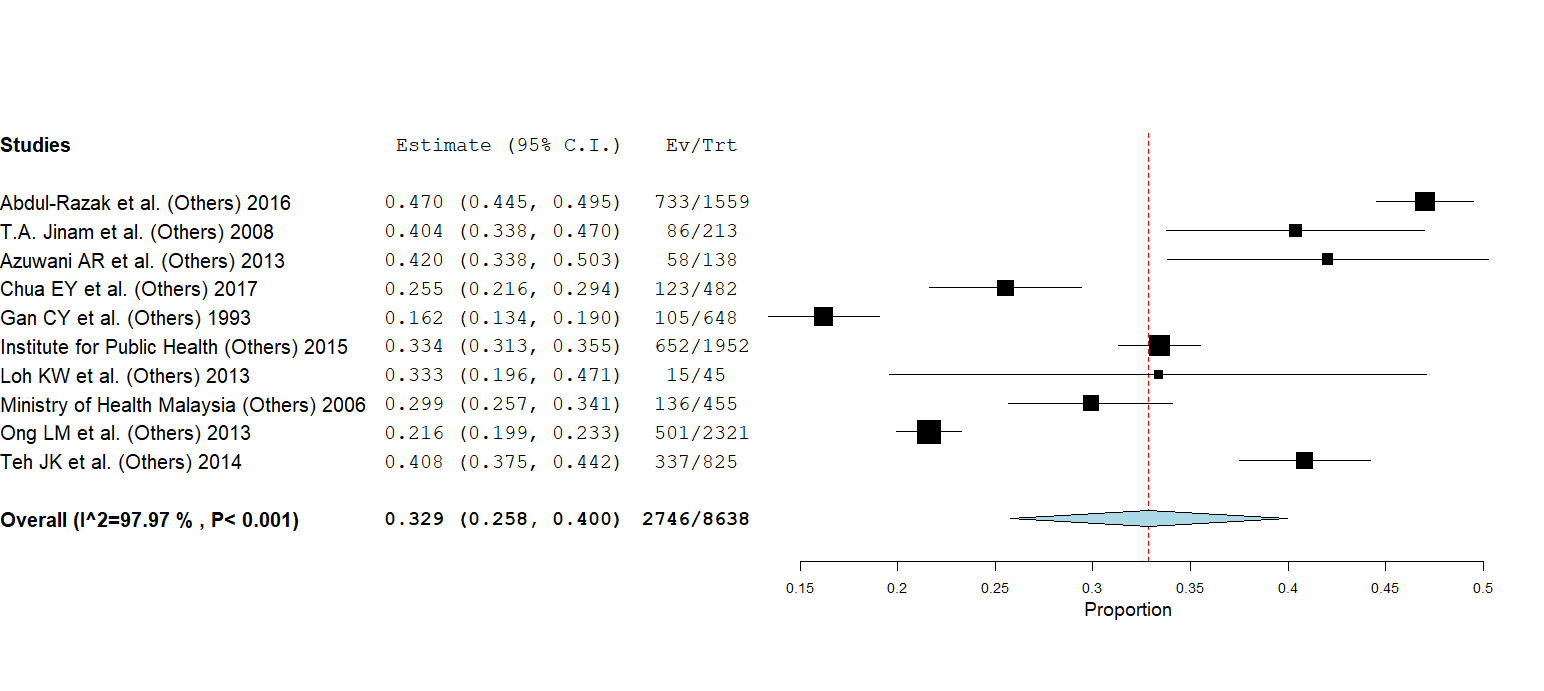
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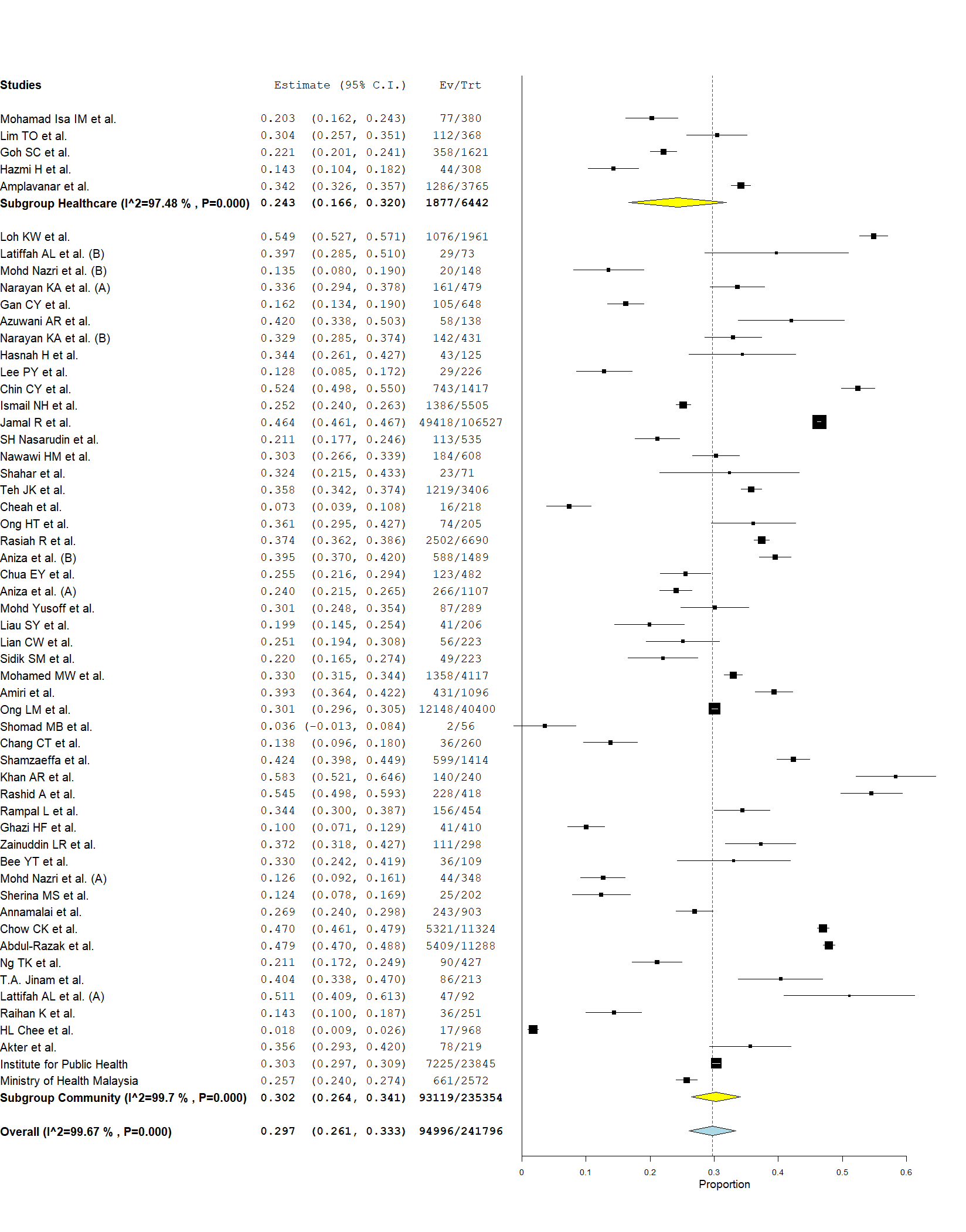
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**D**

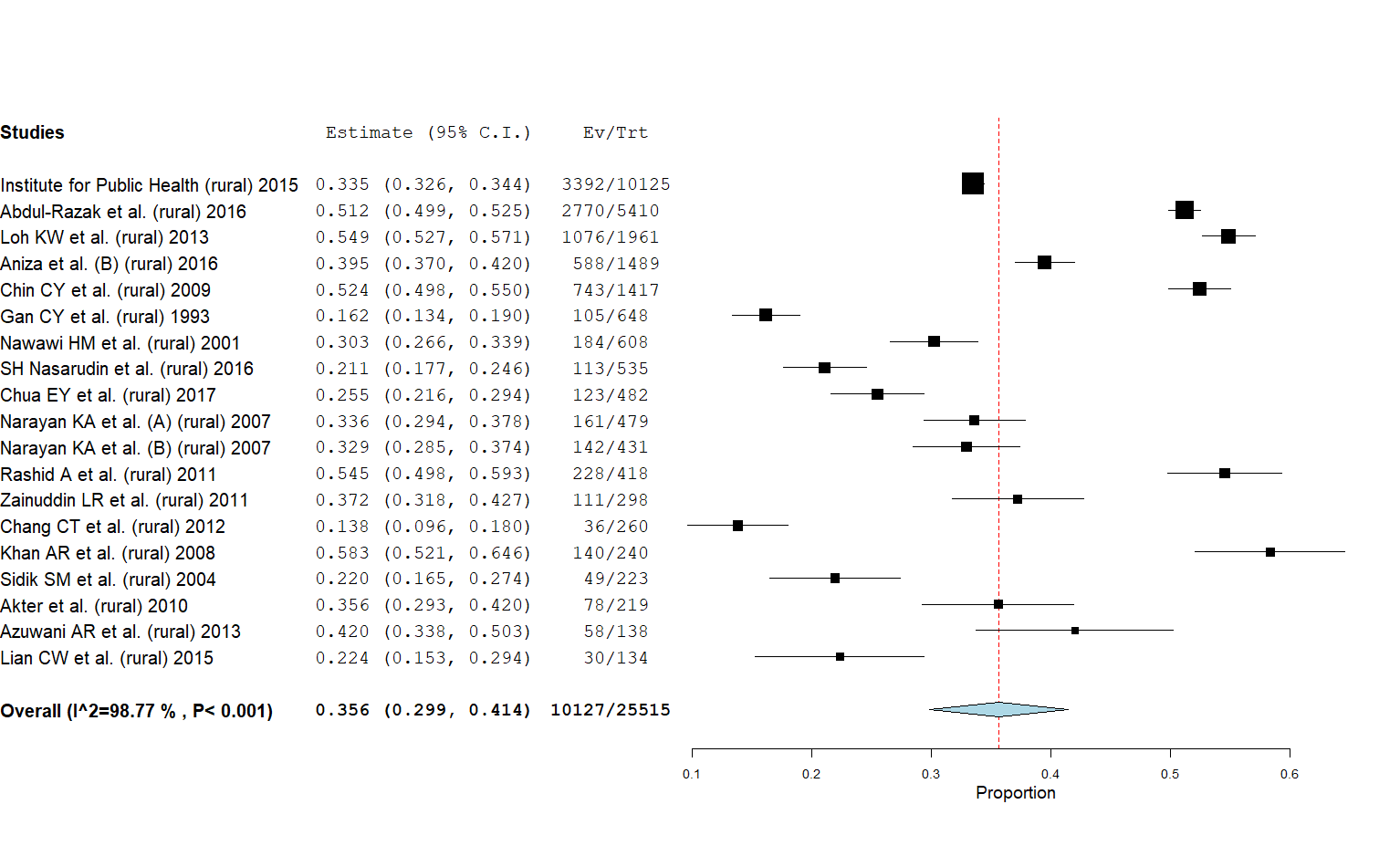
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**Figure 6 Pooled prevalence of hypertension in Malay, Chinese, Indian and other ethnicity.** A: In Malay; B: In Chinese; C: In Indian; D: In other ethnicity.

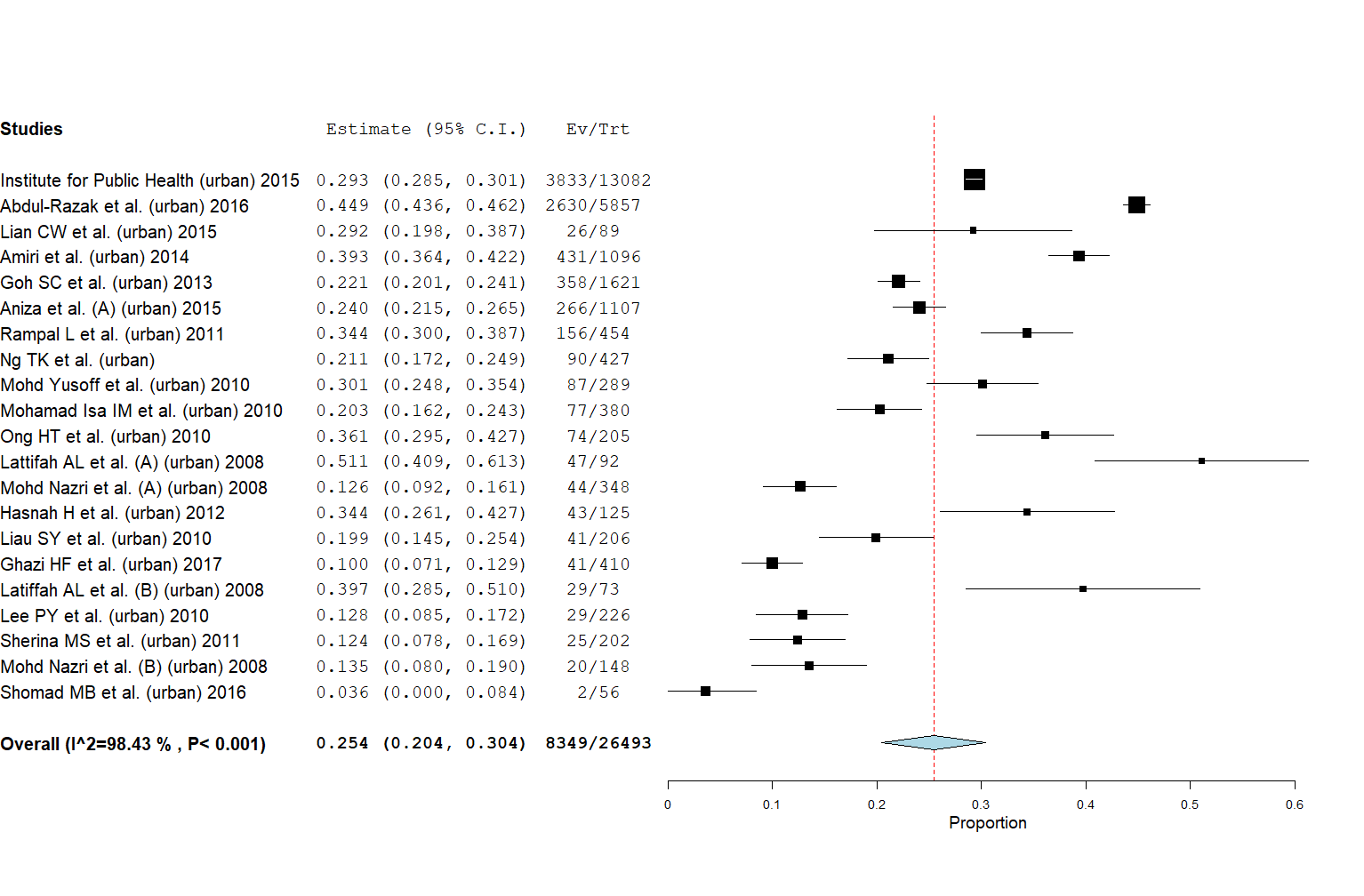
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**Figure 7 Prevalence of hypertension subanalysis by study setting.**

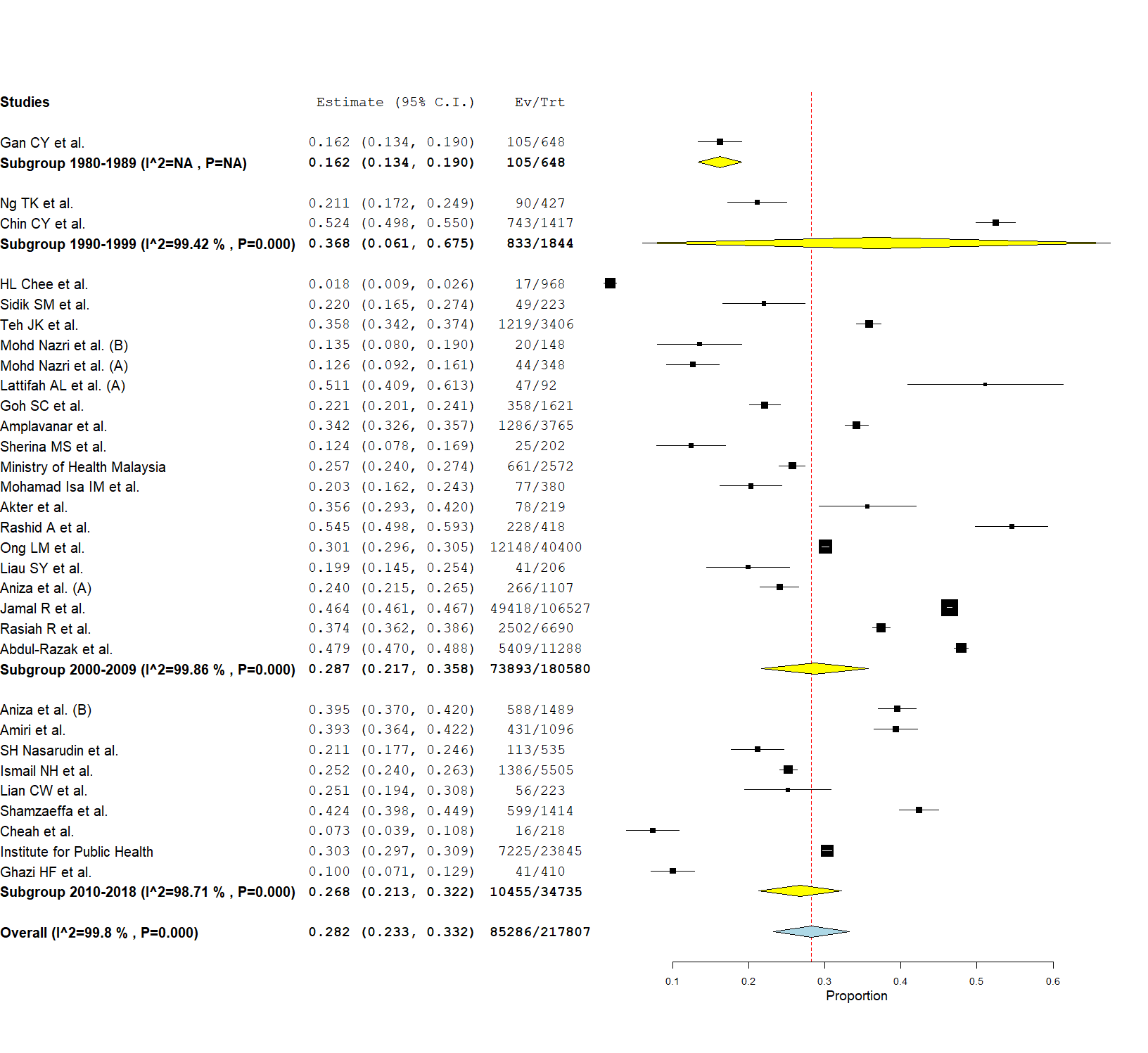
**A**

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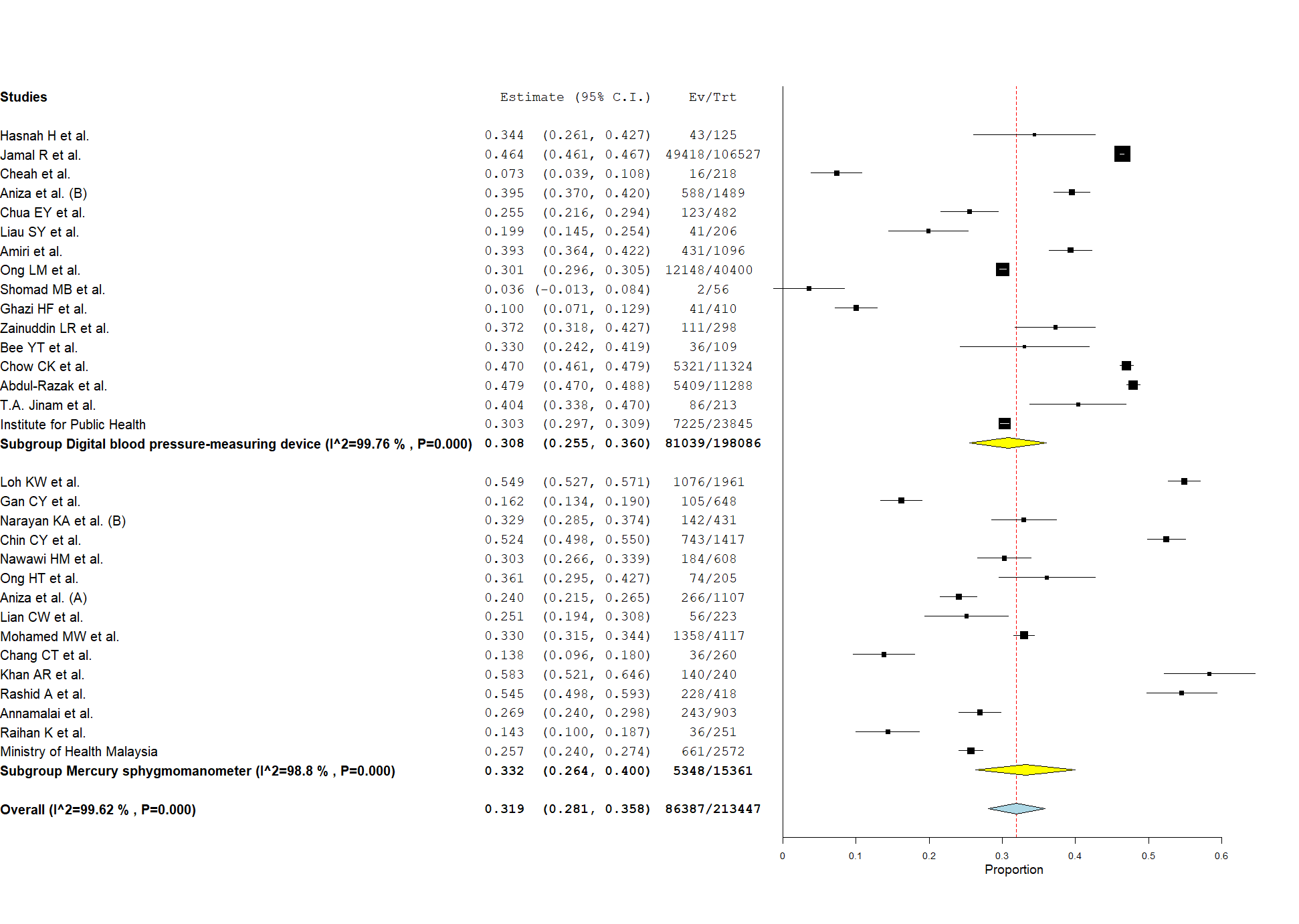
**B**

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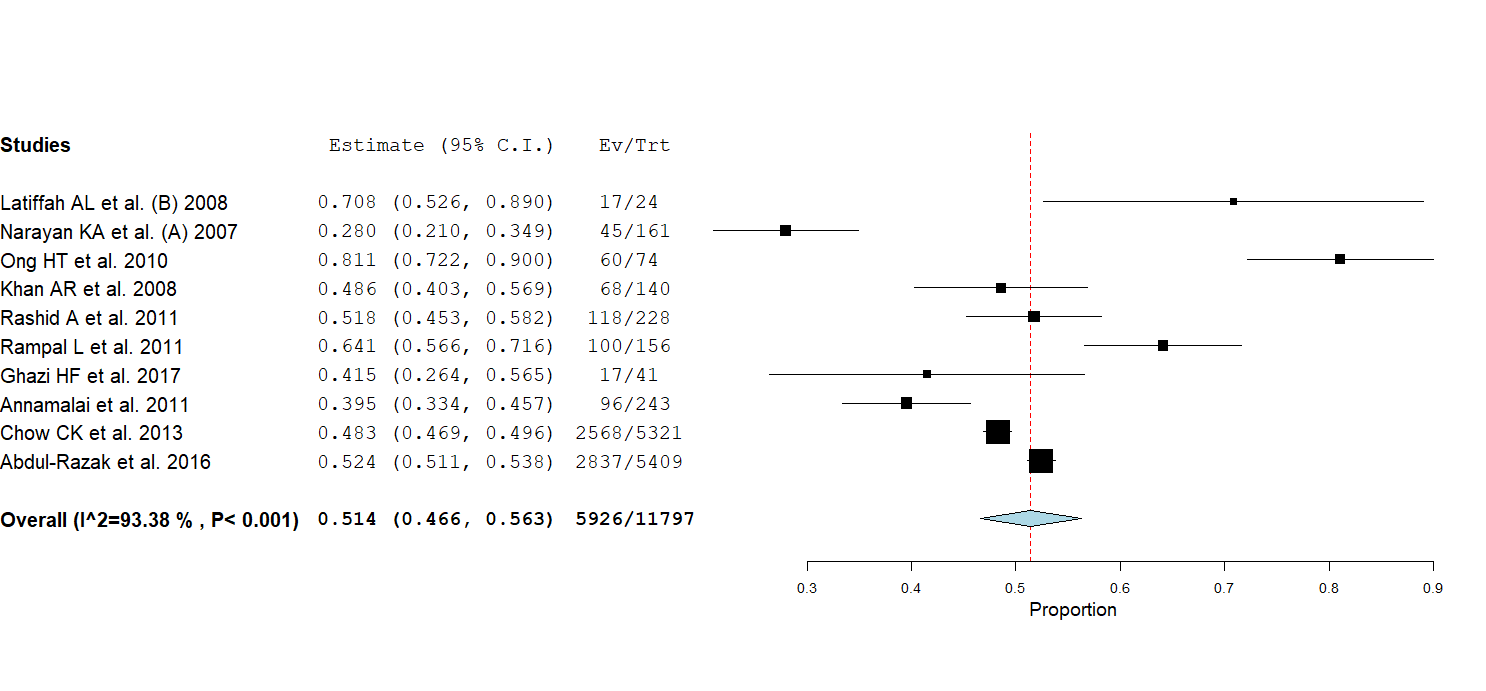
**Figure 8 Pooled prevalence of hypertension in rural and urban area.** A: In rural areas; B: In urban areas.

****

**Figure 9 Overall pooled prevalence of hypertension subgroup by study decade.**

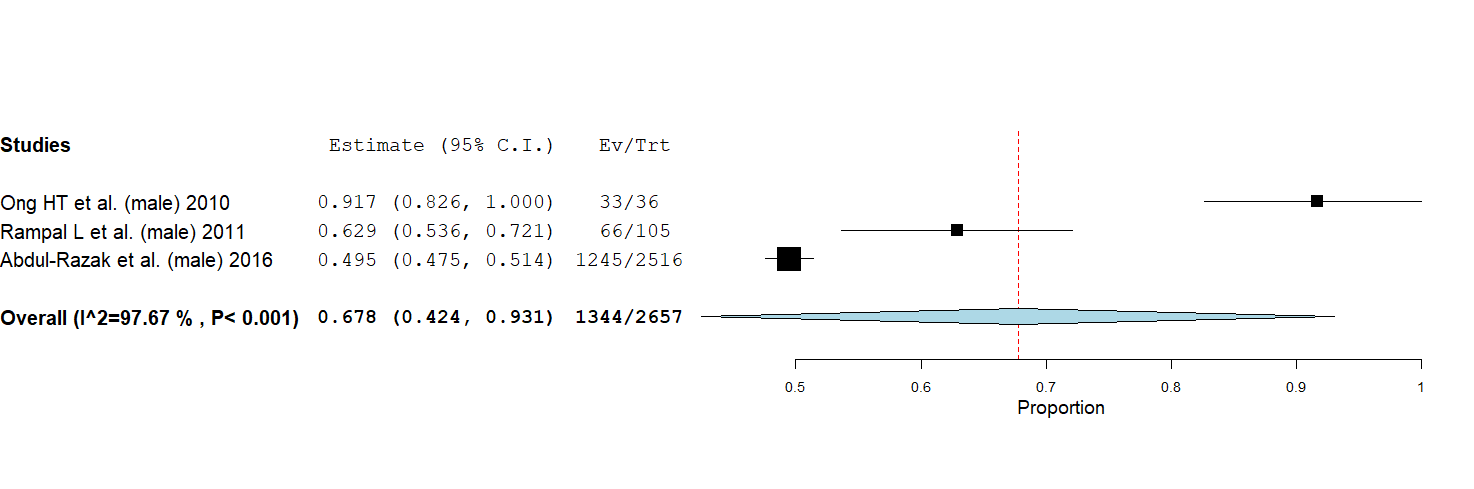
****

**Figure 10 Pooled prevalence of hypertension subanalysis by measurement tools.**

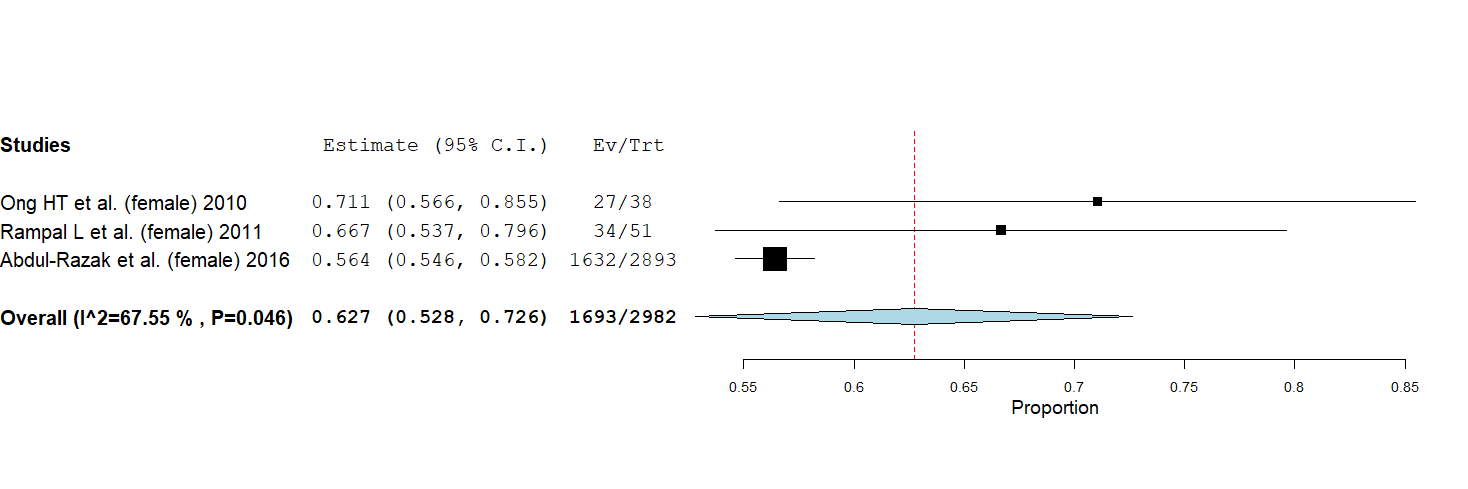
****

**Figure 11 Pooled prevalence of awareness in hypertension.**

**A**

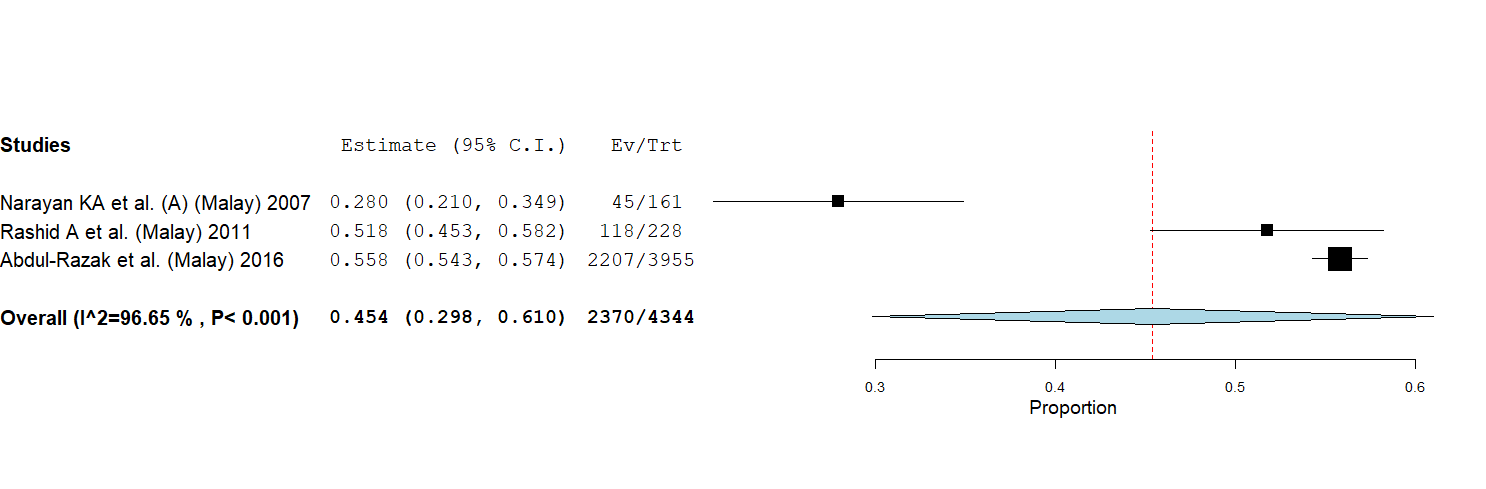
****

B

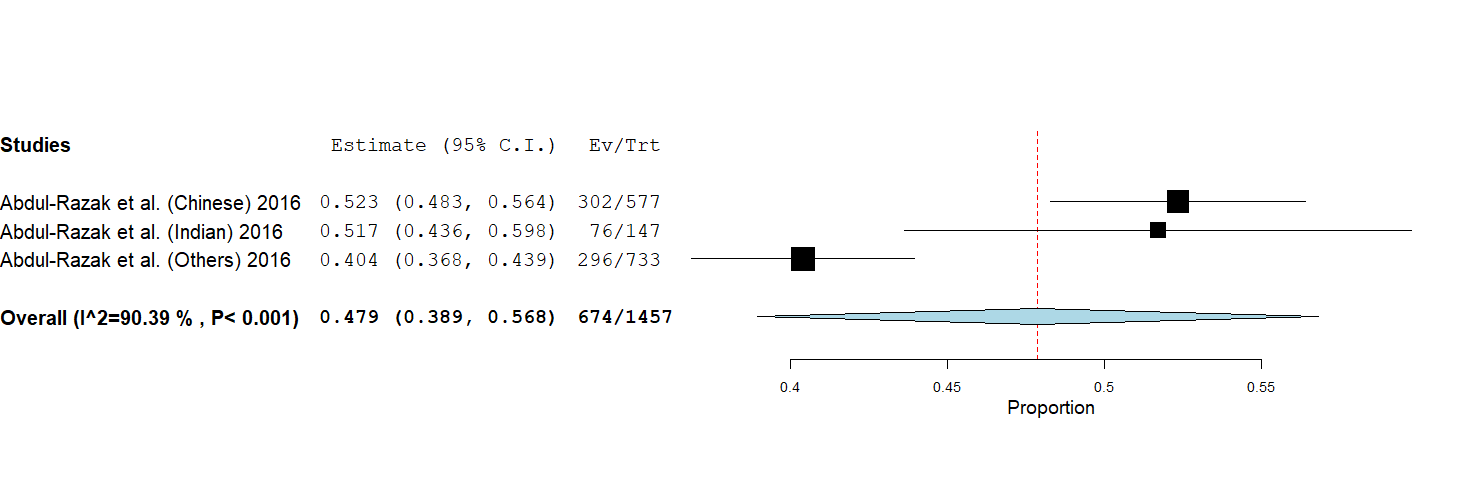
****

**Figure 12 Pooled prevalence of awareness in hypertension in male and female.** A: In male; B: In female.

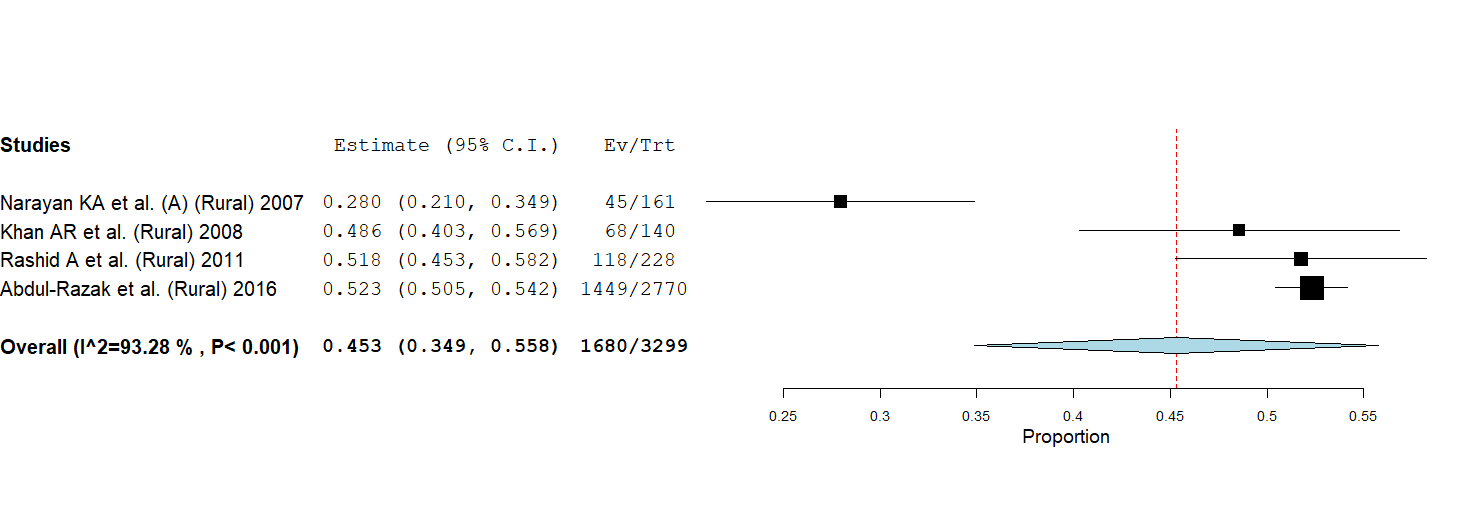
A

****

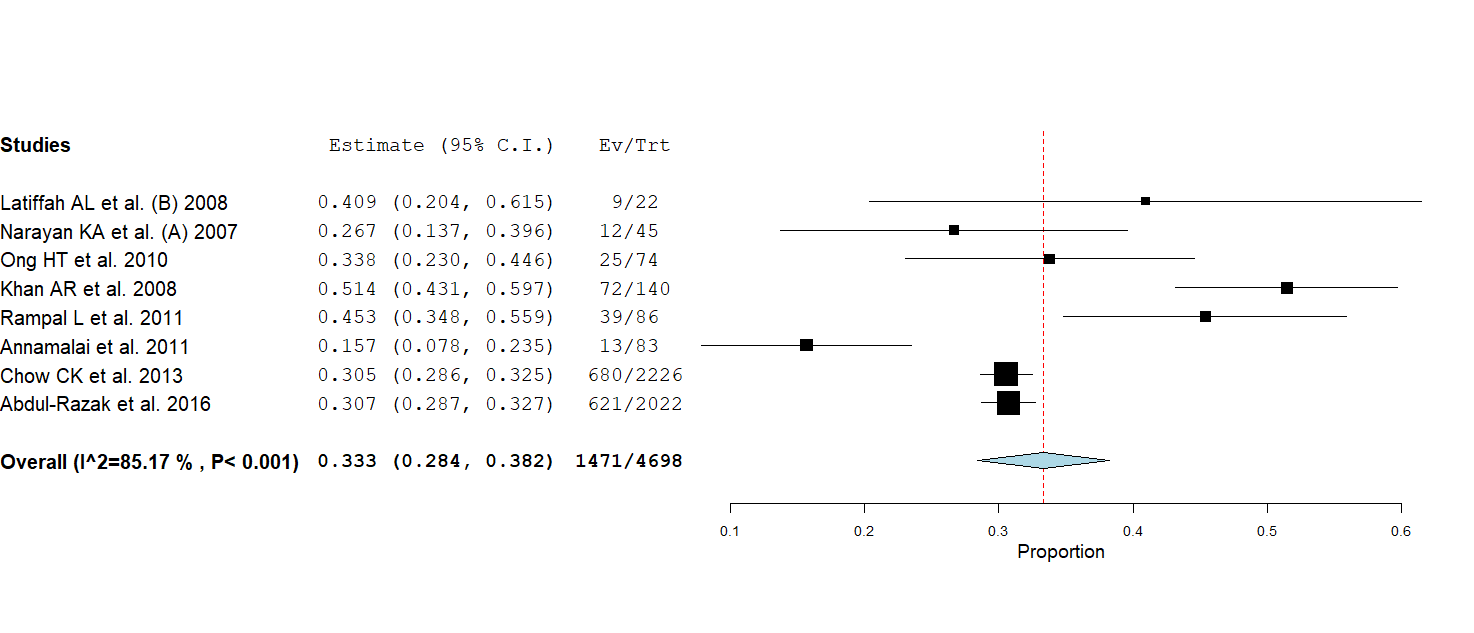
B

****

**Figure 13 Pooled prevalence of awareness in hypertension in Malay and non-Malay.** A: In Malay; B: In non-Malay.

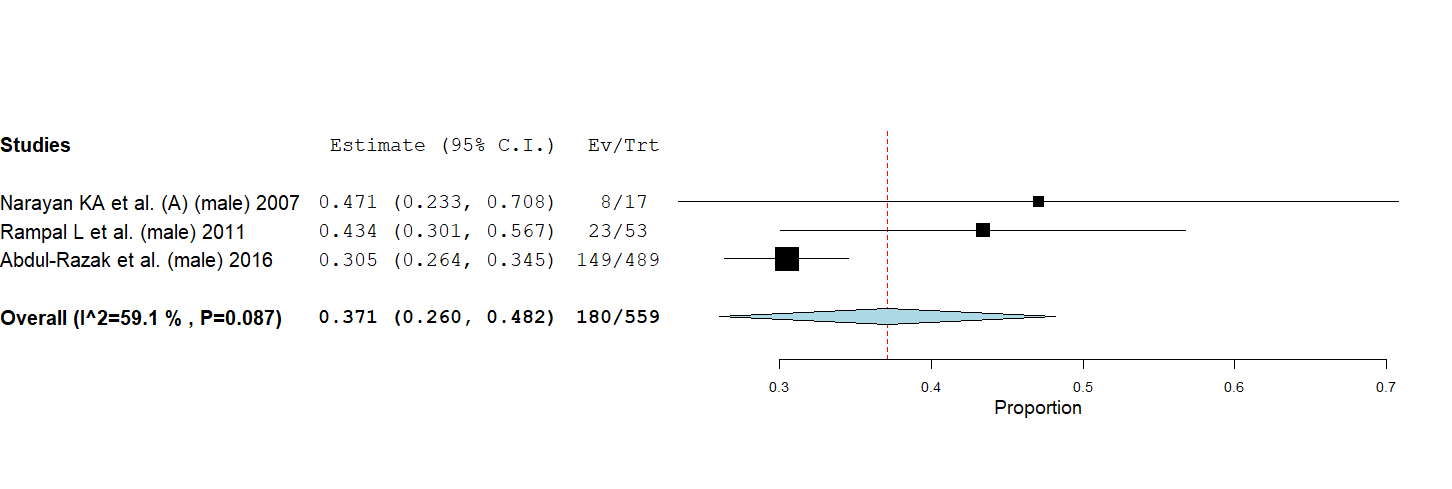
****

**Figure 14 Pooled prevalence of awareness in hypertension in rural areas.**

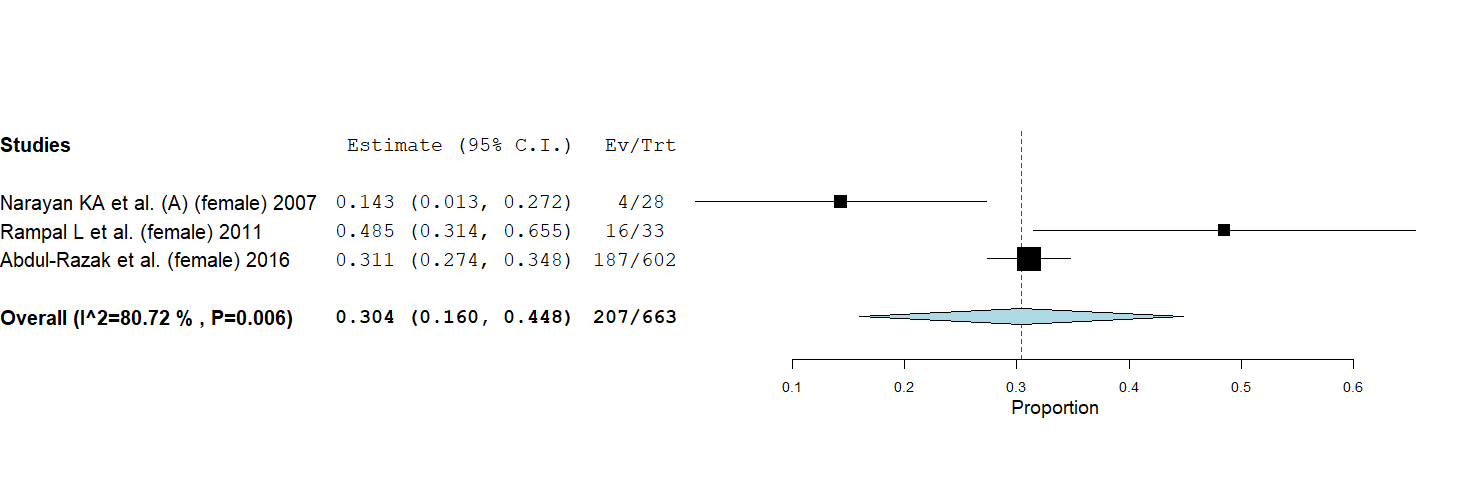
****

**Figure 15 Pooled prevalence of control in hypertension.**

**A**

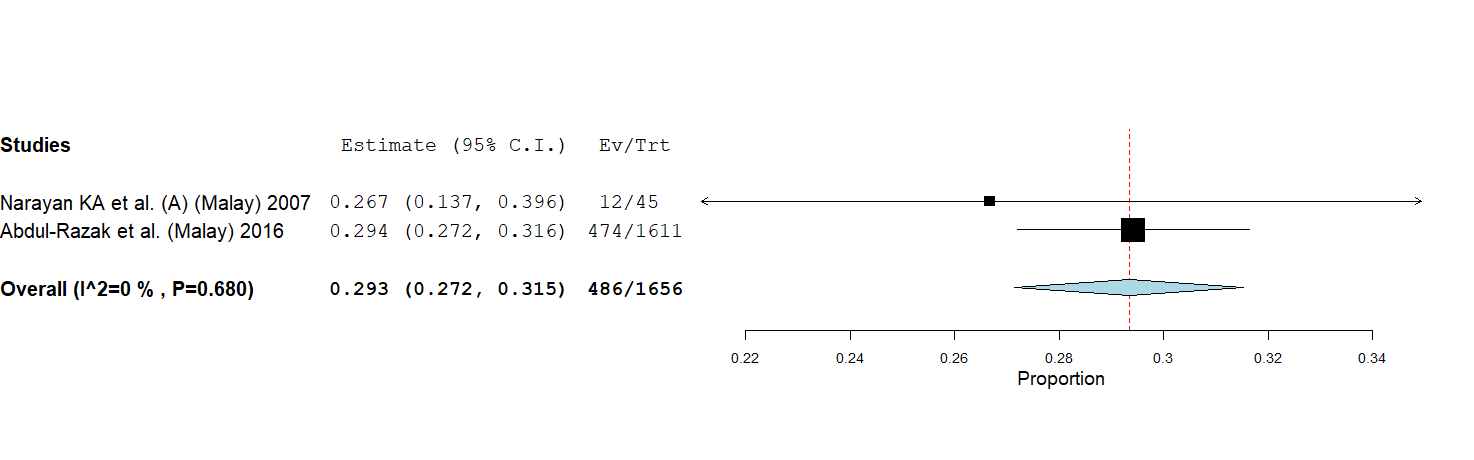
****

**B**

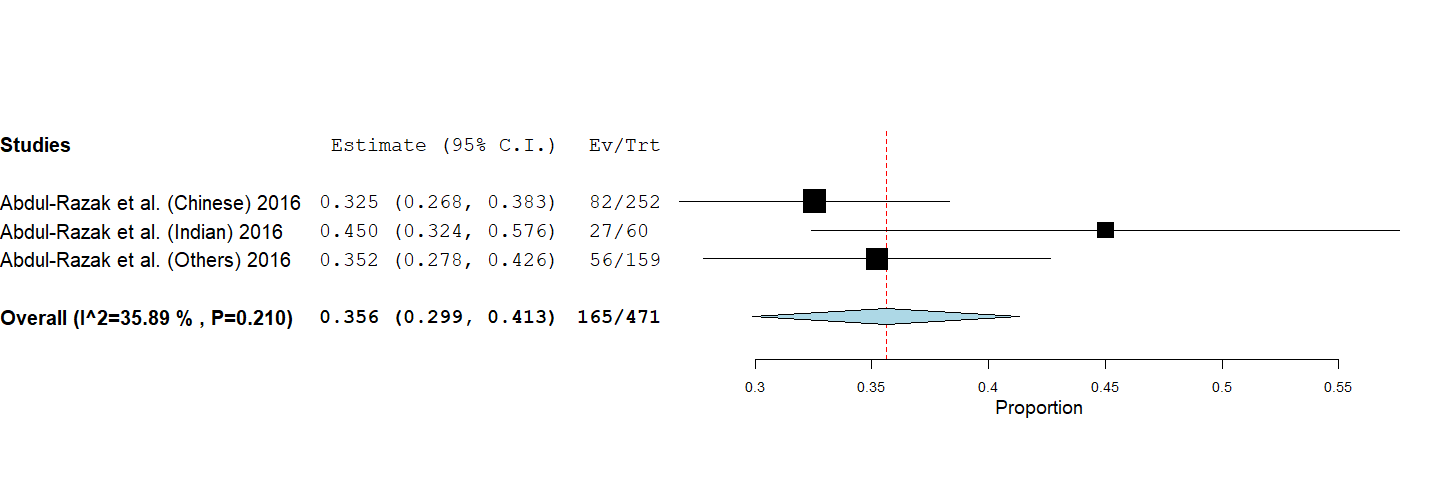
****

**Figure 16 Pooled prevalence of control in hypertension in male and female.** A: In male; B: In female.

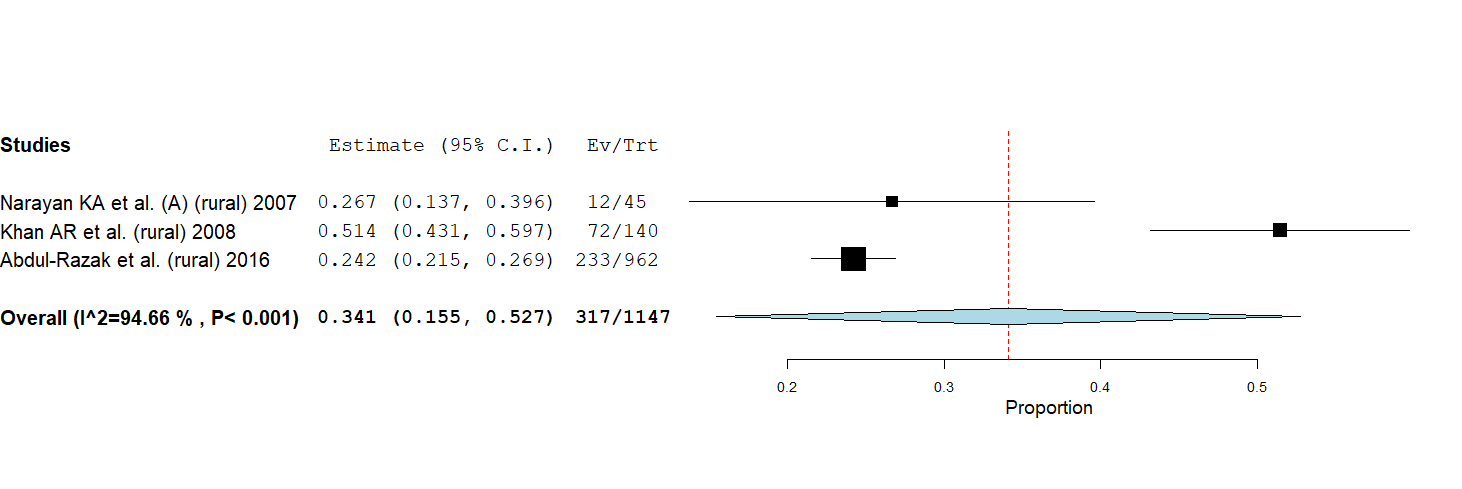
**A**

****

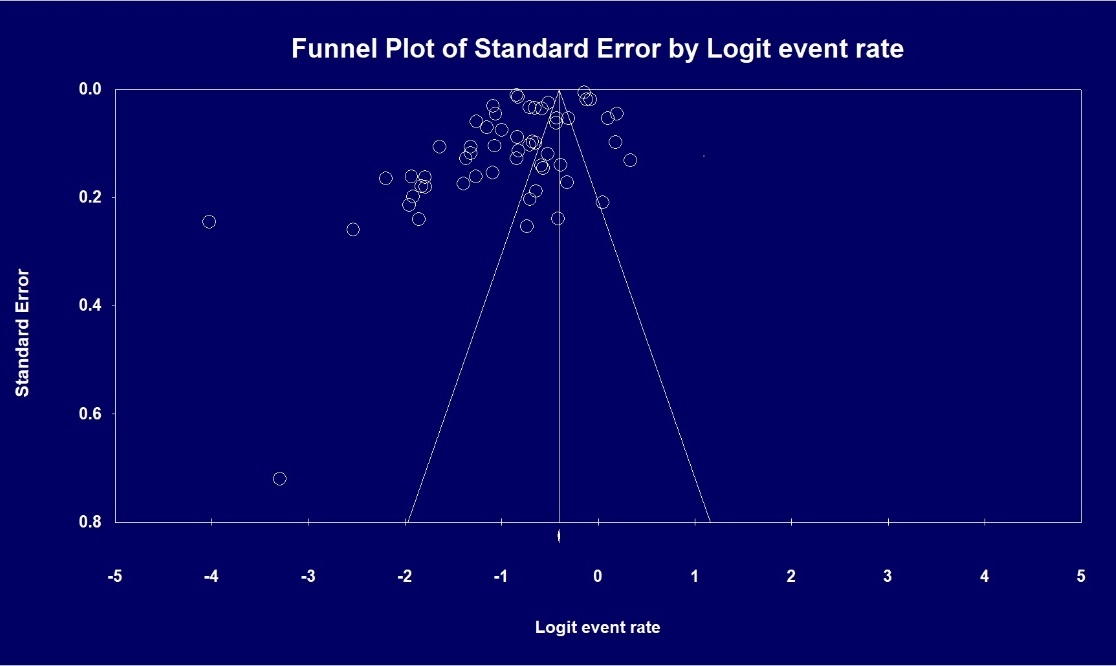
**B**

****

**Figure 17 Pooled prevalence of control in hypertension in Malay and non-Malay.** A: in Malay; B: In non-Malay.

****

**Figure 18 Pooled prevalence of control in hypertension in rural areas.**

****

**Figure 19 Publication bias assessed using funnel plot.**

**Table 1 Prevalence, awareness and control of hypertension in Malaysia**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ref.** | **Sample size, *n*** | **Prevalence of hypertension, %** | **Prevalence of awareness, %** | **Prevalence of control, %** | **Quality of article** |
| Abdul-Razak *et al*[16], 2016 | 11288 | 47.9 | 52.5 | 15.9 | High |
| Jinam *et al*[17], 2008 | 213 | 40.4 | NA | NA | High |
| Akter *et al*[18], 2010 | 219 | 35.6 | NA | NA | High |
| Amiri *et al*[19], 2014 | 1096 | 39.3 | NA | NA | High |
| Amplavanar *et al*[20], 2010 | 3765 | 34.2 | NA | NA | High |
| Aniza *et al*[21], 2015 | 1107 | 24.0 | NA | NA | High |
| Aniza *et al*[22], 2016 | 1489 | 39.5 | NA | NA | High |
| Annamalai *et al*[23], 2011 | 903 | 26.9 | 39.5 | 15.7 | High |
| Azuwani *et al*[24], 2013 | 138 | 42.0 | NA | NA | High |
| Tan *et al*[25], 2008 | 109 | 33.0 | NA | NA | High |
| Chang *et al*[26], 2012 | 260 | 13.9 | NA | NA | High |
| Cheah *et al*[27], 2015 | 218 | 7.3 | NA | NA | High |
| Chee *et al*[28], 2002 | 968 | 1.8 | NA | NA | High |
| Chin *et al*[29], 2009 | 1417 | 52.4 | NA | NA | High |
| Chow *et al*[30], 2013 | 11324 | 47.0 | 48.3 | 12.8 | High |
| Chua *et al*[31], 2017 | 482 | 25.5 | NA | NA | High |
| Gan *et al*[32], 1993 | 648 | 16.2 | NA | NA | High |
| Ghazi *et al*[33], 2017 | 410 | 10.0 | 41.5 | NA | Low |
| Goh *et al*[34], 2013 | 1621 | 22.1 | NA | NA | High |
| Hasnah *et al*[35], 2012 | 125 | 34.4 | NA | NA | High |
| Hazmi *et al*[36], 2015 | 308 | 14.3 | NA | NA | High |
| Ministry of Health Malaysia[37], 2015 | 23845 | 30.3 | NA | NA | High |
| Jamal *et al*[38], 2015 | 106527 | 46.4 | NA | NA | High |
| Khan *et al*[39], 2008 | 240 | 58.3 | 48.6 | 51.4 | High |
| Latiffah *et al*[40], 2008 | 73 | 39.7 | 70.8 | 40.9 | High |
| Latiffah *et al*[41], 2008 | 92 | 51.1 | NA | NA | High |
| Lee *et al*[42], 2010 | 226 | 12.8 | NA | NA | Low |
| Lian *et al*[43], 2015 | 223 | 25.1 | NA | NA | High |
| Liao *et al*[44], 2010 | 206 | 19.9 | NA | NA | High |
| Lim *et al*[45], 1991 | 368 | 30.4 | NA | NA | High |
| Loh *et al*[46], 2013 | 1961 | 54.9 | NA | NA | High |
| Ministry of Health Malaysia[47], 2010 | 2572 | 25.7 | NA | NA | High |
| Mohamed *et al*[48], 2005 | 4117 | 33.0 | NA | NA | High |
| Nazri *et al*[49], 2008 | 148 | 13.5 | NA | NA | High |
| Nazri *et al*[50], 2008 | 348 | 12.6 | NA | NA | High |
| Moy *et al*[51], 2010 | 380 | 20.3 | NA | NA | High |
| Narayan *et al*[52], 2007 | 431 | 33.0 | NA | NA | High |
| Narayan *et al*[53], 2007 | 479 | 33.6 | 28.0 | 27.5 | High |
| Nasarudin *et al*[54], 2016 | 535 | 21.1 | NA | NA | Low |
| Nawawi *et al*[55], 2002 | 608 | 30.3 | NA | NA | High |
| Ng *et al*[56], 1995 | 427 | 21.1 | NA | NA | Low |
| Noor Hassim *et al*[57], 2016 | 5505 | 25.2 | NA | NA | High |
| Ong *et al*[58], 2010 | 205 | 36.1 | 81.1 | 33.8 | High |
| Ong *et al*[59], 2013 | 40400 | 30.1 | NA | NA | High |
| Raihan *et al*[60], 2013 | 251 | 14.3 | NA | NA | High |
| Rampal *et al*[61], 2008 | 454 | 34.4 | 64.1 | 25.0 | High |
| Rashid *et al*[62], 2011 | 418 | 54.6 | 51.8 | NA | High |
| Rasiah *et al*[63], 2015 | 6690 | 37.4 | NA | NA | High |
| Shahar *et al*[64], 2011 | 71 | 32.4 | NA | NA | High |
| Samsudin *et al*[65], 2016 | 1414 | 42.4 | NA | NA | High |
| Sherina *et al*[66], 2011 | 202 | 12.4 | NA | NA | High |
| Shomad *et al*[67], 2016 | 56 | 4.00 | NA | NA | High |
| Sidik *et al*[68], 2004 | 223 | 22.0 | NA | NA | High |
| Teh *et al*[69], 2014 | 3406 | 35.8 | NA | NA | Low |
| Yusoff *et al*[70], 2010 | 289 | 30.1 | NA | NA | High |
| Zainuddin *et al*[71], 201 | 298 | 37.3 | NA | NA | High |

NA: Not available.

**Table 2 Pooled prevalence and 95% confidence interval of hypertension and its subgroup analysis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Number of studies, *n*** | **Prevalence, %** | **95%CI** | | ***P* value** | ***I*2, %** | **Figure** |
| **Overall prevalence** | | | | | | | |
| Malaysia | 56 | 29.7 | 26.1, 33.3 | | < 0.001 | 99.7 | 2 |
| 30 and above | 16 | 40.0 | 35.3, 44.8 | | < 0.001 | 98.9 | 3 |
| **Mean age, yr** |  |  |  | |  |  | 4 |
| 18–29 | 4 | 8.6 | 5.30, 11.90 | | 0.03 | 66.9 |  |
| 30–39 | 3 | 13.5 | 2.9, 29.9 | | < 0.001 | 98.7 |  |
| 40–49 | 17 | 27.9 | 24.9, 30.9 | | < 0.001 | 96.5 |  |
| 50–59 | 4 | 39.4 | 29.3, 49.4 | | < 0.001 | 99.7 |  |
| 60 and above | 6 | 42.8 | 30.2, 55.3 | | < 0.001 | 95.8 |  |
| **Gender** | | | | | | | |
| Male | 26 | 31.4 | 26.5, 36.2 | | < 0.001 | 98.1 | 5A |
| Female | 26 | 27.8 | 20.7, 34.9 | | < 0.001 | 99.5 | 5B |
| **Ethnicity** | | | | | | | |
| Malay | 17 | 37.3 | 32.9, 41.7 | | < 0.001 | 98.9 | 6A |
| Chinese | 8 | 36.4 | 31.6, 41.2 | | < 0.001 | 96.6 | 6B |
| Indian | 10 | 34.8 | 31.2, 38.4 | | < 0.001 | 81.5 | 6C |
| Other | 9 | 32.9 | 25.8, 40.0 | | < 0.001 | 98.0 | 6D |
| **Study setting** |  |  | |  |  |  | 7 |
| Community | 51 | 30.2 | 26.4, 34.1 | | < 0.001 | 99.7 |  |
| Health care setting | 5 | 24.3 | 16.6, 32.0 | | < 0.001 | 97.5 |  |
| **Geographical origin** | | | | | | | |
| Rural | 19 | 35.6 | 29.9, 41.4 | | < 0.001 | 98.77 | 8A |
| Urban | 21 | 25.4 | 20.4, 30.4 | | < 0.001 | 98.43 | 8B |
| **Study decade** |  |  |  | |  |  | 9 |
| 1980-1989 | 1 | 16.2 | 13.4, 19.0 | | NA | NA |  |
| 1990-1999 | 2 | 36.8 | 6.1, 67.5 | | < 0.001 | 99.42 |  |
| 2000-2009 | 19 | 28.7 | 21.7, 35.8 | | < 0.001 | 99.9 |  |
| 2010-2018 | 9 | 26.8 | 21.3, 32.2 | | < 0.001 | 98.7 |  |
| **Blood pressure measurement tools** |  |  |  | |  |  | 10 |
| Mercury sphygmomanometer | 15 | 33.2 | 26.4, 40.0 | | < 0.001 | 98.8 |  |
| Digital blood pressure device | 16 | 30.8 | 25.5, 36.0 | | < 0.001 | 99.8 |  |

CI: Confidence interval.

**Table 3 Pooled awareness, pooled control and subgroup analyses**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Number of studies, *n*** | **Prevalence, %** | **95%CI** | ***P* value** | ***I*2, %** | **Figure** |
| **Overall awareness** | 10 | 51.4 | 46.6, 56.3 | < 0.001 | 93.4 | 11 |
| **Gender** | | | | | | |
| Male | 3 | 67.8 | 42.4, 93.1 | < 0.001 | 97.7 | 12A |
| Female | 3 | 62.7 | 52.8, 72.6 | 0.046 | 67.6 | 12B |
| **Ethnicity** | | | | | | |
| Malay | 3 | 45.4 | 29.8, 61.0 | < 0.001 | 96.7 | 13A |
| Non-Malay | 3 | 47.9 | 38.9, 56.8 | < 0.001 | 90.4 | 13B |
| **Geographical origin** | | | | | | |
| Rural | 4 | 45.3 | 34.9, 55.8 | < 0.001 | 93.3 | 14 |
| Urban | 1 | 54.1 | 52.2, 56.0 | NA | NA |  |
| **Overall control** | 8 | 33.3 | 28.4, 38.2 | < 0.001 | 85.2 | 15 |
| **Gender** | | | | | | |
| Male | 3 | 37.1 | 26.0, 48.2 | < 0.001 | 59.1 | 16A |
| Female | 3 | 30.4 | 16.0, 44.8 | < 0.001 | 80.7 | 16B |
| **Ethnicity** | | | | | | |
| Malay | 2 | 29.3 | 27.2, 31.5 | 0.68 | 0 | 17A |
| Non-Malay | 3 | 35.6 | 29.9, 41.3 | 0.210 | 35.9 | 17B |
| **Geographical origin** | | | | | | |
| Rural | 3 | 34.1 | 15.5, 52.7 | < 0.001 | 94.7 | 18 |
| Urban | 1 | 36.5 | 33.6, 39.3 | NA | NA |  |

CI: Confidence interval; NA: Not available.

**Table 4 Sensitivity analysis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Number of studies, *n*** | **Total sample size, *n*** | **Total hypertensive, *n*** | **Prevalence, %** | **95%CI** | ***P* value** | ***I*2, %** |
| Overall prevalence | 56 | 241796 | 94996 | 29.7 | 26.1, 33.3 | < 0.001 | 99.7 |
| Upon removal of studies with poor quality studies | 51 | 237181 | 93473 | 28.5 | 26.0, 31.2 | < 0.001 | 99.4 |
| Upon removal of studies with nonrandom sampling | 19 | 131904 | 59786 | 29.7 | 26.2, 33.4 | < 0.001 | 98.6 |
| Upon removal of studies with sample size < 100 | 52 | 131904 | 59786 | 28.0 | 25.6, 30.6 | < 0.001 | 99.3 |
| Upon removal of studies with large sample size > 500 | 47 | 28335 | 8943 | 28.4 | 23.3, 33.4 | < 0.001 | 99.2 |
| Upon removal of poor-quality studies, nonrandom studies and studies with sample size < 100 | 12 | 46618 | 16031 | 26.3 | 21.6, 31.6 | < 0.001 | 99.2 |

CI: Confidence interval.