

The different risk factors for isolated diastolic hypertension and isolated systolic hypertension: a national survey

Kun Xie

Huashan Hospital

Xiufang Gao

Huashan Hospital

Liwen Bao

Huashan Hospital

Ying Shan

Huashan Hospital

Haiming Shi

Huashan Hospital

Yong Li (✉ drliyong_hsh@126.com)

Huashan Hospital

Research Article

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Abstract

Background

Hypertension is highly prevalent and is one of the modifiable risk factors for cardiovascular outcomes. Isolated diastolic hypertension (IDH), however, tend to be ignored due to insufficient recognition. We sought to depict the clinical manifestation of IDH and isolated systolic hypertension (ISH) in order to find a more efficient way to improve the management.

Methods

Patients with primary hypertension aged over 18 years were investigated from all over the country using convenience sampling during 2017–2019. IDH was defined as systolic blood pressure (SBP) < 140 mmHg and diastolic blood pressure (DBP) \geq 90 mmHg. ISH was defined as SBP \geq 140 mmHg and DBP < 90 mmHg.

Results

Totally 8548 patients were screened and 8475 participants were included.

The average age was 63.67 ± 12.78 years and male accounted for 54.4%. Among them, 361 (4.3%) had IDH and 2096 had ISH (24.7%). Patients with IDH (54.84 ± 13.21 years) was much younger. Aging turned out to be negatively associated with IDH but positively associated with ISH. Logistic analysis showed BMI was a significant risk factor for IDH (OR 1.30, 95%CI 1.05–1.61, $p = 0.018$), but not for ISH (OR 1.05, 95%CI 0.95–1.16, $p = 0.358$). Moreover, smoking was significantly associated with IDH (OR 1.36, 95%CI 1.04–1.78, $p = 0.026$) but not with ISH (OR 1.04, 95%CI 0.90–1.21, $p = 0.653$).

Conclusions

Patients with IDH were much younger and the prevalence decreased with aging. BMI and smoking were remarkably associated with IDH rather than ISH. Keeping fit and giving up smoking might be particularly efficient in the management of young patients with IDH.

Trial registration:

NCT03862183, retrospectively registered on March 5, 2019

Background

Hypertension is highly prevalent and is one of the most modifiable risk factors for cardiovascular mortality and morbidity. Isolated diastolic hypertension (IDH) and isolated systolic hypertension (ISH) are two special types of hypertension. However, compared to ISH, IDH tend to be ignored either by patients or by physicians. As reported in the PEACE Study, 86.1% of those IDH were untreated[1].

Recently, the significance of IDH has been challenged. McEvoy et al. reported in JAMA that IDH, by 2017 ACC/AHA definitions[2], was not associated with increased cardiovascular outcomes[3]. This study might be limited by the population age, and the results should be cautiously generalized to the young patients. As Yue et al. found that in 21441 participants, patients aged 35–59 years with stage 1 hypertension defined by the 2017 ACC/AHA guideline had a significantly increased risk of CVD risks over a 15-year period. However, in patients aged ≥ 60 years, stage 1 hypertension was not associated with increased CVD risks[4].

Actually, in a recent network meta-analysis, each 10mmHg reduction in systolic BP and each 5mmHg reduction in diastolic BP have been reported to be associated with a lower risk of cardiovascular mortality, cardiovascular events, and stroke[5]. Lee et al. reported in Circulation that among 6 million participants aged 20–39 years, stage 1 IDH turned out to be associated with higher CVD risks after 13.2 years follow up[6]. Thus, the management of IDH in young patients should be highlighted rather than ignored.

However, the adherence to antihypertensive medication is far from optimal, especially in younger patients. Tiffany et al. reported that among 23.8 million hypertensive adults, the nonadherence rate was around 31%, and the highest nonadherence rate of 58.1% was seen in the youngest population aged 18–34 years in the U.S. in 2015[7].

Besides antihypertensive medication, lifestyle management also plays a fundamental role in the management of hypertension concerning the high nonadherence rate in young patients[8–10]. But life style management may have a different effect on different types of hypertension like IDH and ISH, which are considered to have different pathophysiological mechanisms and will result in various features[11]. However, our knowledge of IDH is still insufficient, as is stated in the guidelines [2, 12]. We sought to depict the clinical manifestation of IDH to find a more efficient way to improve the management of IDH.

Methods

We carried out a nationwide cross-sectional study (UPPDATE) in 15 cities from 2017–2019 using convenience sampling. Patients with hypertension, either under life style management or antihypertensive medication, were included. The inclusion criteria were 1) ≥ 18 years old; 2) primary hypertension; 3) who can provide the written informed consent. The exclusion criteria were 1) secondary hypertension, 2) severe liver or renal disease, 3) mental illness, or active cancer.

The research protocol was approved by the Ethics Committee of Huashan Hospital, Fudan University (2017-282-1).

All methods were performed in accordance with the relevant guidelines and regulations.

Hypertension was defined according to the 2018 ESC/ESH guideline for the management of hypertension using office BP. Therefore, IDH was defined as SBP < 140mmHg and DBP \geq 90mmHg; ISH was defined as SBP \geq 140mmHg and DBP < 90 mmHg; Systolic and diastolic hypertension (SDH) was defined as SBP \geq 140mmHg and DBP \geq 90mmHg; Normotension was defined as SBP < 140mmHg and DBP < 90 mmHg. Elevated BMI was defined as BMI \geq 25 kg/m².

Statistical analysis was conducted using STATA 13.1. Two-sides Student's t-test or ANOVA were used for continuous variables, and Chi-square test was used for categorical variables. Both forward stepwise method and backward stepwise method were used to reach the logistic regression model. P < 0.05 was considered statistically significant.

Results

Totally 8548 participants were screened, and 73 of them were excluded due to missing covariates. Finally, 8475 participants were included. The average age was 63.67 \pm 12.78 years, male accounted for 54.4%. 18.5% of them had a habit of smoking, and 89.4% were under antihypertensive agents. The average BMI was 24.83 \pm 3.85 kg/m² (Table 1).

Table 1
Demographic characters of the total patients and patients in different BP categories

	Total (n = 8475)	Normotension (n = 3434)	IDH (n = 361)	ISH (n = 2096)	SDH (n = 2584)	p
Age (yrs)	63.67 ± 12.78	65.11 ± 11.90	54.84 ± 13.21	66.87 ± 12.09	60.39 ± 13.12	< 0.001
Male (%)	4610 (54.4%)	1820(53.0%)	233 (64.5%)	1062 (50.7%)	1495 (57.9%)	< 0.001
BMI (kg/m ²)	24.83 ± 3.85	24.50 ± 3.38	26.47 ± 6.53	24.70 ± 3.77	25.15 ± 3.92	< 0.001
Smoking (%)	1560 (18.5%)	538 (15.8%)	98 (27.4%)	354 (17.1%)	570 (22.2%)	< 0.001
Antihypertensive agents (%)	7567 (89.4%)	3264(95.1%)	296 (82.0%)	1852 (88.4%)	2155 (83.5%)	< 0.001
SBP (mmHg)	142.50 ± 18.66	127.78 ± 8.06	126.72 ± 14.43	150.01 ± 11.52	158.17 ± 17.47	< 0.001
DBP (mmHg)	84.54 ± 12.73	76.43 ± 6.82	97.89 ± 14.40	79.17 ± 6.52	97.79 ± 9.76	< 0.001
LDL (mmol/L)	2.86 ± 1.09	2.74 ± 1.03	3.07 ± 1.45	2.87 ± 1.06	3.03 ± 1.13	< 0.001
TC (mmol/L)	4.86 ± 1.34	4.73 ± 1.26	4.94 ± 1.19	4.78 ± 1.26	5.14 ± 1.51	< 0.001
HDL (mmol/L)	1.28 ± 0.34	1.29 ± 0.35	1.23 ± 0.33	1.29 ± 0.33	1.27 ± 0.32	0.06
TG (mmol/L)	2.06 ± 1.67	1.94 ± 1.54	2.35 ± 1.74	1.91 ± 1.41	2.36 ± 2.01	< 0.001
DM (%)	1634 (20.2%)	709 (21.6%)	56 (15.9%)	473 (23.7%)	396 (16.2%)	< 0.001
CAD (%)	1435 (17.8%)	541 (16.5%)	42 (11.9%)	417 (21.0%)	435 (17.8%)	< 0.001
HF (%)	179 (2.2%)	64 (2.0%)	4 (1.1%)	57 (2.9%)	54 (2.2%)	0.07
Statin (%)	4461 (57.6%)	1834(58.2%)	158 (46.1%)	1210 (64.3%)	1259 (53.2%)	< 0.001
BP: blood pressure. IDH: isolated diastolic hypertension. ISH: isolated systolic hypertension.						

Among them, 361 patients had IDH, 2096 patients had ISH, 2584 patients had SDH and 3434 patients had normotension. Patients with IDH were the youngest (54.84 ± 13.21 years) among those with ISH

(66.87 ± 12.09 years), SDH (60.39 ± 13.12 years) and Normotension (65.11 ± 11.90 years). However, patients with IDH had the highest BMI (26.47 ± 6.53 kg/m²) among those with ISH (24.70 ± 3.77 kg/m²), SDH (25.15 ± 3.92 kg/m²) and normotension (24.50 ± 3.38 kg/m²). The smoking rate was also the highest in patients with IDH (27.4%) compared to those with ISH (17.1%), SDH (22.2%) and normotension (15.8%). While patients using antihypertensive agents were the least in IDH (82.0%) among those with ISH (88.4%), SDH (83.5%) and normotension (95.1%). The use of statin was also the least in IDH (46.1%) among those with ISH (64.3%), SDH (53.2%) and normotension (58.2%) (Table 1).

The proportion of IDH of the total population decreased with aging, while the proportion of ISH increased with aging (Table 2, Fig. 1). Logistic analysis showed the gradually decreasing risk of IDH and the continuously increasing risk of ISH for every 10-year aging. This means aging was one of the predictors of ISH but was inversely associated with IDH (Table 3, Fig. 2). Younger patients were more likely to have IDH, while older patients were more likely to have ISH.

Table 2
The distribution of different types of hypertension according to age

Age categories (Years)	Normotension	IDH N (%)	ISH N (%)	SDH
< 25	23(0.7)	4 (1.1)	10 (0.5)	14(0.5)
25–34	24(0.7)	19 (5.3)	12 (0.6)	52(2.0)
35–44	151(4.4)	63 (17.5)	90 (4.3)	249(9.6)
45–54	452(13.2)	101 (28.0)	210 (10.0)	550(21.3)
55–64	986(28.7)	93 (25.8)	516 (24.6)	716(27.7)
65–74	1059(30.8)	52 (14.4)	670 (32.0)	618(23.9)
75–84	575(16.7)	26 (7.2)	470 (22.4)	306(11.8)
≥ 85	164(4.8)	3 (0.8)	118 (5.6)	79(3.1)
Total	3434(100)	361 (100)	2096 (100)	2584(100)
IDH: isolated diastolic hypertension. ISH: isolated systolic hypertension.				

Table 3
Trends in the OR for the prevalence of IDH or ISH

	Model 1		Model 2		Model 3	
	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p
Prevalence of IDH						
Age						
< 25	Reference	-	Reference	-	Reference	-
25–34	2.53(0.82–7.89)	0.108	2.40(0.77–7.49)	0.130	2.33(0.75–7.29)	0.145
35–44	1.51(0.53–4.33)	0.443	1.47(0.51–4.22)	0.474	1.43(0.50–4.12)	0.505
45–54	1.00(0.35–2.77)	0.968	0.98(0.34–2.77)	0.965	1.01(0.36–2.87)	0.982
55–64	0.49(0.17–1.40)	0.183	0.50(0.18–1.42)	0.193	0.53(0.18–1.50)	0.228
65–74	0.26(0.09–0.75)	0.013	0.27(0.09–0.77)	0.014	0.28(0.10–0.82)	0.020
75–84	0.22(0.08–0.67)	0.008	0.23(0.08–0.69)	0.009	0.26(0.09–0.77)	0.015
≥ 85	0.10(0.02–0.45)	0.003	0.10(0.02–0.45)	0.003	0.11(0.02–0.52)	0.005
Male	1.55(1.25–1.94)	< 0.001	1.32(1.05–1.65)	0.015	1.16(0.90–1.48)	0.249
Elevated BMI	1.55 (1.25–1.91)	< 0.001	1.34(1.08–1.66)	0.008	1.30 (1.05–1.61)	0.018
Smoking	1.70(1.34–2.16)	< 0.001	1.35(1.03–1.76)	0.029	1.36(1.04–1.78)	0.026
Antihypertensive Agents	0.52(0.40–0.69)	< 0.001	0.76(0.57–1.02)	0.063	0.73(0.54–0.97)	0.031
Prevalence of ISH						
Age						
< 25	Reference	-	Reference	-	Reference	-

Model 1 was unadjusted model. Model 2 was adjusted for age and gender. Model 3 was adjusted for elevated BMI, age categories, gender, smoking and antihypertensive agents.

IDH: isolated diastolic hypertension. ISH: isolated systolic hypertension.

	Model 1		Model 2		Model 3	
25–34	0.52(0.21–1.29)	0.159	0.53(0.21–1.33)	0.179	0.49(0.19–1.24)	0.131
35–44	0.80(0.39–1.65)	0.541	0.81(0.39–1.67)	0.568	0.81(0.39–1.67)	0.566
45–54	0.78(0.38–1.58)	0.492	0.78(0.39–1.58)	0.494	0.79(0.39–1.61)	0.517
55–64	1.18(0.59–2.37)	0.645	1.17(0.58–2.35)	0.662	1.23(0.61–2.48)	0.556
65–74	1.59(0.79–3.19)	0.193	1.57(0.78–3.15)	0.205	1.66(0.82–3.34)	0.157
75–84	2.12(1.05–4.28)	0.035	2.10(1.04–4.23)	0.038	2.25(1.11–4.54)	0.024
≥ 85	1.97(0.95–4.06)	0.068	1.96(0.95–4.04)	0.070	2.13(1.03–4.42)	0.041
Male	0.82(0.74–0.90)	< 0.001	0.87(0.78–0.96)	0.005	0.85(0.76–0.95)	0.003
Elevated BMI	0.98 (0.89–1.08)	0.693	1.05(0.95–1.16)	0.330	1.05 (0.95–1.16)	0.358
Smoking	0.88(0.77–1.00)	0.047	1.03(0.89–1.19)	0.723	1.04(0.90–1.21)	0.563
Antihypertensive Agents	0.88(0.75–1.03)	0.113	0.73(0.62–0.86)	< 0.001	0.72(0.61–0.85)	< 0.001
Model 1 was unadjusted model. Model 2 was adjusted for age and gender. Model 3 was adjusted for elevated BMI, age categories, gender, smoking and antihypertensive agents.						
IDH: isolated diastolic hypertension. ISH: isolated systolic hypertension.						

Additionally, patients with IDH had higher BMI ($26.47 \pm 6.53 \text{ kg/m}^2$) than those with ISH ($24.70 \pm 3.77 \text{ kg/m}^2$). In logistic analysis, after adjusting for age, gender, smoking history and antihypertensive agents, BMI still remained as a significant risk factor for IDH (OR 1.30, 95%CI 1.05–1.61, $p = 0.018$), but not for ISH (OR 1.05, 95%CI 0.95–1.16, $p = 0.358$), which means the BMI target has not been achieved well and remained to be taken seriously, particularly in patients with IDH (Table 3, Fig. 2).

Moreover, smoking was more prevalent in IDH (27.4%) than in ISH (17.1%). Logistic analysis showed that, after adjusting for age, gender, BMI and antihypertensive agents, smoking still remained significantly associated with IDH (OR 1.36, 95%CI 1.04–1.78, $p = 0.026$) but not with ISH (OR 1.04, 95%CI 0.90–1.21, $p = 0.653$). Therefore, besides BMI, smoking is another recommendation life style change that should be seriously concerned (Table 3, Fig. 2).

Discussion

Our study found that IDH and ISH were two distinctive types of hypertension. Both of them were age-dependent, however, IDH was more prevalent in young and middle-aged patients, while ISH was more prevalent in middle-aged and old patients. Obesity and smoking, not only the risk factor for hypertension but also lifestyle-changing targets, were significantly associated with IDH but not ISH. Therefore, the management of BMI and smoking habits should be concerned more seriously and might be particularly efficient in young patients with IDH.

Recently, diastolic BP was not considered as important as systolic BP, and IDH was challenged if it should be regarded as the risk factor for incident cardiovascular outcomes by some studies[3, 13, 14]. Moreover, Mahajan et al. reported that few patients with IDH were aware of having hypertension, and were poorly managed in the survey of China PEACE Million Persons Project[1].

But in a worldwide study, Yan Li et al. reported that IDH was remarkably associated with cardiovascular events, particularly in those below age 50[15]. Additionally, IDH was associated with urinary albumin/creatinine ratio, particularly in patients below the age of 55[16]. The inconsistent results may mainly lie in the age of the study population. It has already been recognized that after 50 years old, the systolic BP continuously increases with age, while on the other hand, the diastolic BP starts to decrease with age. Therefore, IDH is more prevalent in young and middle-aged patients, but ISH is more prevalent in middle-aged and old patients[8, 17]. Thus, the management of IDH should be highlighted rather than ignored in younger patients[18].

Obesity and smoking are the two major risk factors for the development of hypertension, which can be modified by improving lifestyle management[2, 19]. As obesity and smoking are highly prevalent in young adults, it would be particularly essential to prevent cardiovascular disease by early lifestyle management in the young. BMI trajectories have been found to be significantly associated with the incident of hypertension in young adults, which suggested the importance of early prevention[20]. Recently, smoking has been confirmed to be associated with increased risk of masked hypertension, especially in heavy smokers[21]. In our study, BMI was remarkably associated with the prevalence of IDH but was not associated with ISH, which might suggest that lowering BMI might be an effective way to lower diastolic BP and improve the management of IDH. Smoking was significantly associated with the prevalence of IDH as well. It was not associated with ISH, either. Thus, giving up smoking might also be especially efficient in the management of IDH. More longitudinal studies are needed in the early IDH interference and management.

The weakness of our study was that it was a cross-sectional study. We could not tell the causal relationship between BMI, smoking, and IDH. But we could find that more efforts were needed in lifestyle management concerning BMI and smoking in patients with IDH than those with ISH. Keeping fit and giving up smoking might be critical to lower the diastolic BP and to manage IDH.

However, the strength of our study was that it was a multi-center study recruiting patients from all over the country with a relatively large sample.

Additionally, our study population had a wide span of age, which facilitated us to depict the features of IDH in relatively young patients and helped fill the insufficiency of data in patients with IDH. The result suggested the importance of lifestyle management in the early-onset patients with IDH, besides antihypertensive agents.

In conclusion, IDH and ISH had totally different features. Patients with IDH were much younger, and the prevalence decreased with aging. On the contrary, patients with ISH were much older, and the prevalence increased with aging. As IDH was a disease of young and middle-aged patients, the management of such type of hypertension should be highlighted rather than ignored. BMI and smoking status were the two factors especially associated with IDH rather than ISH. Besides antihypertensive agents, keeping fit, and giving up smoking might contribute a lot to the management of young patients with IDH.

Declarations

Ethics approval and consent to participate

The research protocol was approved by the Ethics Committee of Huashan Hospital, Fudan University (2017-282-1). All of the patients included in our study have provided the written informed consent.

Consent for publication

All of the patients included in our study have provided the consent for publication.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The Authors declare that there is no conflict of interest

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Author's contributions

Prof. KX contributed to the investigation, the analysis, the interpretation of data and drafted the manuscript. Prof. XG contributed to the organization of the investigation and revised the manuscript. Prof. LB contributed to the management of the investigation and the database. Prof. YS contributed to

review and approve the version to be published. Prof. HS reviewed and approved the version to be published. Prof. YL contributed to the design and supervision of the study and approved the version to be published. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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Not applicable.

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Figures

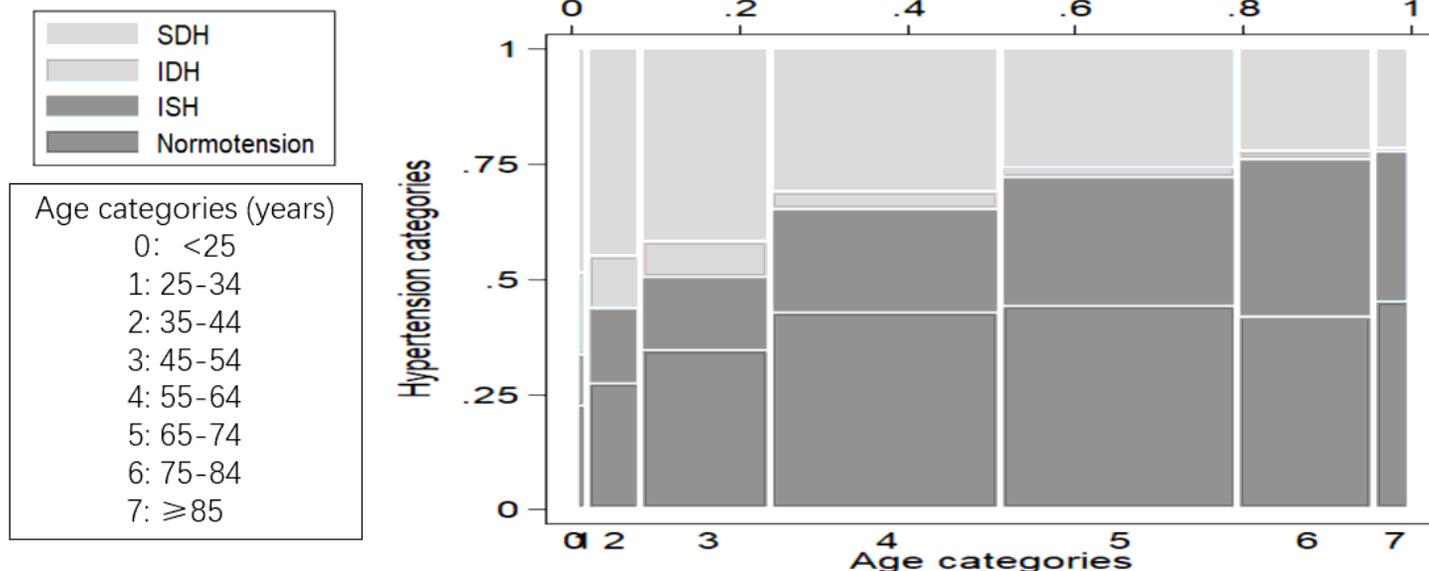


Figure 1

The proportion of IDH and ISH in patients with hypertension according to age categories. The proportion of IDH and ISH in patients with hypertension according to age categories

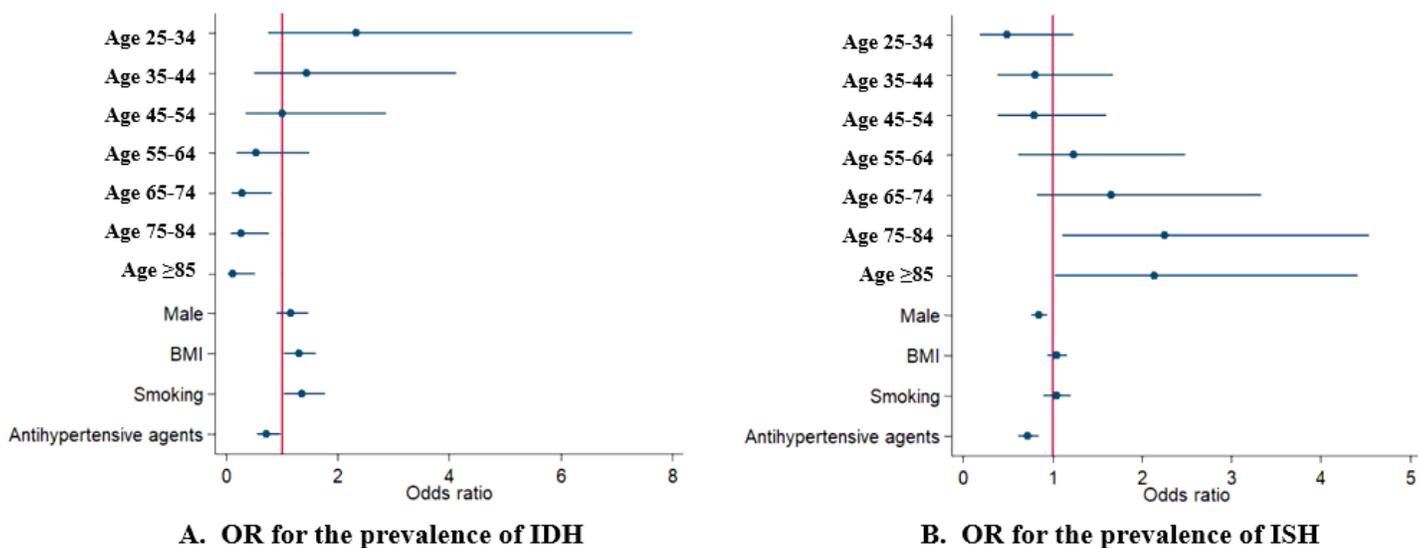


Figure 2

OR for the prevalence of IDH and ISH A. OR for the prevalence of IDH; B. OR for the prevalence of ISH. IDH: isolated diastolic hypertension. ISH: isolated systolic hypertension.

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