

# The Prevalence and Risk Factors of Isolated Systolic Hypertension Among Elderly Chinese Population

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## Research article

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## **Abstract**

## **Objective**

To investigate the prevalence status of the isolated systolic hypertension (ISH) among the elderly Chinese population and analyze risk factors of ISH.

## **Methods**

The survey was conducted from September 2015 to September 2016 enrolling 1269 people aging above 80 in the urban community in Chengdu, China. The participants were recruited by using a stratified cluster sampling method. The average blood pressure of an individual was obtained by using a standardized mercury sphygmomanometer to measure the blood pressure twice after a 10-minute seated rest.

## **Results**

The prevalence of ISH was 53.0% among the elderly population; the ISH was accounted for 82.2% of all hypertension cases. The prevalence of ISH of males and females was 54.7% and 51.5%, respectively, without significant differences ( $P= 0.25$ ). The prevalence of ISH in the 80–84 group, 85–89 group, and > 90 group were 52.5%, 53.0%, and 60.0%, respectively without significant differences ( $P$  for trend = 0.36). Multivariate logistic regression analysis showed that drinking alcoholic, obesity, and heart rate (HR) > 75 beats/min were all positively correlated to the incident of ISH; however, physical exercise was negatively correlated to the occurrence of ISH.

## **Conclusion**

53.0% of the elderly Chinese population aged above 80 has ISH. The gender and physical exercise are not the independent risk factor of ISH. But drinking alcoholic, obesity and HR > 75 are significantly related to the occurrence of ISH.

## **Introduction**

Isolated systolic hypertension (ISH) affects primarily the elderly who age above 60 leading to an increased pulse pressure (PP)[1]. The PP is a strong independent predictor of cardiovascular death according to Hozawa A et al[2]. The increased PP relates to high blood pressure which may result from an increased systolic blood pressure (SBP). It is reported that the increased SBP significantly raises the risk of cardiovascular disease in the elderly[3]. And the increased SBP causes greater harm than the increased diastolic blood pressure(DBP), to the cardiovascular system leading to a higher rate of death.[4]. The risk of cardiovascular death in patients with ISH is higher than those who has isolated diastolic hypertension (IDH), or systolic-diastolic hypertension (SDH)[5, 6]. The Systolic Hypertension in the Elderly Program

(SHEP) suggests that timely antihypertension therapy for patients with ISH can effectively reduce the risk of cardiovascular death and significantly extend the life expectancy[7].

It is estimated that ISH accounts for about 50% of the elderly hypertension while the proportion of ISH is even higher along with the age growth[8]. From 2011 to 2015, the total population of the very elderly population ( $\geq 80$  years old) increased from 22 million to 26 million in China[9]. The occurrence of ISH may result from different life-style of each individual, and related to different living habits from various regions of the country. The study of the prevalence of ISH can help to improve the epidemiology understanding of the disease. However, there's lack of data regarding to the prevalence of ISH in China. It is reported that the prevalence of ISH was 45.4% in retirement centers for army officers[10], however, the survey was not conducted in the community. Our study aimed to investigate the prevalence and related factors of ISH in the very elderly Chinese population.

## Methods

### Study Subjects

A cross-sectional survey was conducted in the city of Chengdu from September 2015 to September 2016, using a stratified cluster sampling method to collect the data from the representative samples. Three of the eleven districts of Chengdu were randomly chosen for the study. They were Jinjiang district, Qingyang district and Longquan district. Two sub-districts were randomly selected in each of the three districts where two communities were chosen without preference from each of the sub-district for data collection. A total of 1468 research subjects aged above 80 from the 12 randomly selected communities were included for our investigation.

Inclusion criteria were: 1) more than 3 years of residence in the community; 2) aged 80 years or above. Excluded criteria were: those who were diagnosed neurologic and psychological diseases, renal failure, or end-stage cancer. Some study subjects were excluded from the study as they did not agree to sign on the consent form and refused to answer the questionnaire or decline to measure the blood pressure. At the end, 1,269 participants were enrolled in the study, where 620 males and 649 females were included.

### Data Collection

24 well trained research staffs were recruited to assist with the measurements. Cardiovascular survey was done referring to the reported method[11]. A questionnaire was designed where items such as demographic characteristics, medical history, family history of hypertension, lifestyle risk factors, etc. were included. The participants were required to be bare-foot with light clothes, and take off the hats when they were measured height and weight. Waist circumference (WC) was measured as the minimum circumference between the inferior margin of the ribcage and the crest of the iliac[12]. After 10-minute seated rest, blood pressure was measured using standardized mercury sphygmomanometers to record the systolic blood pressure (SBP) and diastolic blood pressure (DBP). The mean of two reads was calculated for data analysis.

# **Definitions**

ISH is defined as a condition where people have SBP  $\geq$  140 mmHg and DBP  $<$  90 mmHg without a history of hypertension, or people is receiving antihypertension treatment with DBP hitherto lower than 90 mmHg. According to the Seventh Report of the Joint National Committee, patients with SBP  $\geq$  140 mmHg and/or DBP  $\geq$  90 mmHg, and/or a history of hypertension and currently receiving antihypertensive drug treatment were diagnosed as hypertension[13]. Overweight is defined as people has a BMI between 25.0 and 29.9 ( $\text{kg}/\text{m}^2$ ), and obesity was considered as people has a BMI  $\geq$  30 ( $\text{kg}/\text{m}^2$ ) [11]. Abdominal obesity was defined as a WC  $\geq$  85 cm for men and a WC  $\geq$  80 cm for women[14]. Hypertriglyceridemia and hypercholesterolemia were defined as TG  $\geq$  2.26 mmol/L and TC  $\geq$  6.22 mmol/L, respectively[15]. Smoking was defined as smoking at least once per day and smoking continuously  $\geq$  1 year recently or quitting smoking in less than 3 years. Drinking was considered drinking at least once a week, and drinking continuously  $\geq$  1 year recently or quitting alcohol less than 3 years.

## **Biochemical Analysis**

After 12 h of overnight fasting, 5 ml of venous blood from the participant was collected into tubes. All blood samples were sent to the Clinical Laboratory Center of Second People's Hospital. Blood glucose, lipids and uric acid were measured in all blood samples. Total cholesterol (TC), triglyceride (TG) and blood glucose were measured by enzyme method. Uric acid (UA) was determined by phosphotungstic acid method.

## **Statistical Analysis**

EPI DATA 3.02 database software was used to record the data from questionnaires. Data input was done by two researchers at the same time with data correction. Categorical variables were presented as frequency (percentage), and Chi-square test or Fisher exact test were used for inter-group comparison. For continuous variables, if conforming to normal distribution, mean  $\pm$  SD was used to represent data and two-sample t-test was used for inter-group comparison. Multivariate logistic regression model was used to estimate the odds ratios (ORs) and corresponding 95% confidence intervals (CIs) to investigate the significant risk factors of ISH. Duplex bar chart was used to describe the trends of SBP, PP and prevalence of ISH among age groups and BMI groups, and Cochran-Armitage test was used to test the trend of ISH prevalence and generalized linear model was used to test the trend of SBP and PP. SAS software was used for statistical description test for differences, and multivariate analysis.

# **Results**

## **Characteristics of Study Subjects**

A total of 1269 research subjects with average age of  $83.5 \pm 3.1$  years were enrolled in the study. Of all the 1269 subjects, 620 (48.9%) were males and 649 (51.1%) females with no significant age difference between the two genders groups. Smoking rate for males was 17.7% while only 6.6% females smoke.

18.7% male participants had routine drinking while 2.2% female counterparts had the same habit. 23.7% of the candidates did physical exercises. The BMI and WC of males were significantly higher than those of females. The SBP of females was significantly higher than males. The DBP and heart rate had no significant difference between the two genders (Table 1).

Table 1  
Baseline characteristics of the very elderly population

	Overall (n = 1269)	Male (n = 620)	Female (n = 649)	P
Age (average, years old)	83.5 ± 3.1	83.7 ± 3.1	83.4 ± 3.1	0.11
Age group (%), years old)				0.53
80 to ≤84	878(69.19)	423(68.23)	455(70.11)	
85 to ≤89	321(25.30)	165(26.61)	156(24.04)	
90onward	70(5.52)	32(5.16)	38(5.86)	
WC (cm)	88.6 ± 10.5	89.7 ± 10.2	87.6 ± 10.6	0.0005
SBP (mmHg)	149.1(21.6)	147.1(20.1)	150.9(22.8)	0.001
Diastolic pressure/mmHg,mean (SD)	74.1(12.1)	74.5(11.5)	73.8(12.6)	0.30
Heart rate/min,mean (SD)	76.0(12.4)	76.4(13.6)	75.7(11.1)	0.37
TC,mmol/L, mean (SD)	4.8(0.9)	4.6(0.9)	5.0(0.9)	0.001
TG, mmol/L, mean (SD)	1.4(0.7)	1.3(0.6)	1.5(0.7)	0.0004
FPG, mmol/l, mean (SD)	5.7(2.2)	5.8(2.3)	5.5(2.0)	0.04
2hPG, mmol/L, mean (SD)	8.6(3.8)	8.7(2.8)	8.5(4.5)	0.24
uric acid, mmol/L, mean (SD)	333.3(117.8)	359.6(118.5)	308.2(111.5)	0.001

WC, Waist circumference; SBP, Systolic blood pressure; FPG, Fasting Plasma Glucose; PG, Plasma Glucose.

## SBP and PP level

The mean SBP of 80–84 years group, 85–89 years group and > 90 years group were 148.8 mmHg, 149.3 mmHg, and 151.6 mmHg, respectively. No significant increasing trend could be observed from either between the three age groups, or from different sex groups ( $P$  for trend = 0.29) (Fig. 1A). Besides, PP difference (74.3 mmHg, 75.9 mmHg, 79.1 mmHg) gradually increased along with age grow (80–84, 85–89, > 90 years) ( $P$  for trend = 0.02) (Fig. 1B).

## Prevalence of ISH

819 candidates were hypertensive patients accounting for 64.5% of all study subjects. Among the hypertension patients were 673 individuals having ISH. The prevalence of ISH was 53%. The prevalence of ISH for males and females were 54.7% and 51.5%, respectively, with no significant difference ( $P=0.25$ ). The prevalence of ISH in the 80–84 group, 85–89 group, and > 90 group were 52.5%, 53.0%, and 60.0%, respectively. The prevalence of ISH did not increase significantly ( $P$  for trend = 0.36) along with age grow (Fig. 2). This phenomenon could be observed in both males and females. The prevalence of ISH in the  $BMI < 25$  group,  $25 \leq BMI < 30$  group and  $BMI \geq 30$  group were 53.5% 47.4% and 80.3%, respectively. The prevalence of ISH was higher in the  $BMI \geq 30$  group than in the  $BMI < 25$  group ( $P < 0.0001$ ).

## Risk Factors Related to ISH

A multivariate logistic regression model analysis was applied to identify the risk factors leading to ISH among the elderly Chinese population. We found that drinking, obesity, and  $HR > 75$  beats/min were risk factors leading to ISH. At the meantime, physical exercise was negatively correlated to ISH(Table 2).

Table 2  
Multivariable-adjusted ORs and 95% CI for ISH among the very elderly population of Chengdu community

Variable	OR (95% CI)	$P$
Current drinking	1.76 (1.20–2.58)	0.0039
Obesity ( $BMI \geq 30$ )	1.39 (0.94–2.04)	0.04
Physical exercise	0.72 (0.49–1.08)	0.03
Heart rate > 75 beats/min	1.72 (1.39–2.17)	< .0001

ORs, Odds ratios; CI, Confidence interval; ISH, Isolated systolic hypertension;  
 BMI, Body Mass Index.

## Discussion

In this study, we investigate the prevalence of ISH among the elderly Chinses citizens aging above 80 where 1269 candidates voluntarily participated in our research. The mean SBP of 80–84 years group, 85–89 years group and > 90 years group were 148.8 mmHg, 149.3 mmHg, and 151.6 mmHg, respectively. No significant increasing trend could be observed from either between the three age groups, or both from different sexes groups show this characteristic ( $P$  for trend = 0.29). The prevalence of ISH in the population aged  $\geq 80$  y was 53.0% in 2015–2016 in Chengdu. And it accounts for 82.2% of all included hypertension cases. No prevalence differences between male and female was observed. After statistical analysis, the risk factors leading to ISH includes drinking alcoholic, obesity, and  $HR > 75$  beats/min. Routine physical exercise was negatively correlated to ISH. Moreover, those who had  $BMI \geq 30$  was significantly in a higher risk of BMI than who had  $BMI < 25$  ( $P < 0.0001$ ).

The prevalence of ISH in many areas was higher than previously reported for elderly populations [16, 17], also higher than the previously reported prevalence in China's retirement centers for army officers (45.4%)[18]. The major difference between the old soldiers and normal people may lie on the routine tough training in their early lives. The trainings not only make them skillful but may also exert great positive impact on their health conditions. Our finds that routine physical exercise was negatively correlated to ISH indirectly prove our hypothesis. Previous studies reported that the prevalence of ISH in females was higher in the general population[19, 20]. However, among the population aged above 80 who's living in Chengdu, there was no significant difference in the prevalence of ISH between males and females. It indicates that it may be the age than the gender playing a more important role for ISH development. In the above 80-year-old population, BMI was closely related to ISH. BMI over 30 (obesity) is a risk factor leading to ISH. Other risk factors include drinking alcoholic and HR > 75 which accords with the previous studies[21, 22].

Our findings suggest that a healthy lifestyle including routine exercises, keeping a proper BMI and quit drinking may be important to prevent ISH. Our study also has limitation. We conducted a cross-sectional investigation, which had some limitation in confirming the cause and effect.

## Conclusions

In conclusion, the prevalence of ISH in population aged over 80 in Chengdu was 53%. The risk factors leading to ISH include drinking alcoholic, obesity, HR > 75 and lack of daily exercises. A community-based effective prevention and screening strategy is needed to address this situation.

## Abbreviations

ISH, Isolated systolic hypertension;

PP, Pulse pressure;

SBP, Systolic blood pressure;

DBP, Diastolic blood pressure;

BMI, Body Mass Index;

IDH, Isolated diastolic hypertension;

SDH, Systolic-diastolic hypertension;

SHEP, Systolic Hypertension in the Elderly Program;

WC, Waist circumference;

TC, Total cholesterol;

TG, Triglyceride;

UA, Uric acid;

ORs, Odds ratios;

CIs, Confidence intervals;

## Declarations

### Ethics approval and consent to participate

The research program was approved by the Second People's Hospital of Chengdu Ethics Committee, and all the participants voluntarily signed the consent form before proceeding.

#### Consent for publication

Written informed consent was obtained from all participants.

#### Conflict of Interests

The authors declare no conflict of interests.

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## Author Contributions:

QKZ, RHX, and XBH contributed to study concept and design, acquisition of data, analysis, and interpretation of data, and preparation of the manuscript. JXL, YL and LYQY contributed to study concept and design, interpretation of data, and preparation of the manuscript. YZ contributed to preparation of the manuscript. TJ contributed to acquisition of data and statistical analysis.

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## *Availability of data and materials*

The analyzed data sets generated during the study are available from the corresponding author on reasonable request.

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## Figures

Figure 1-A

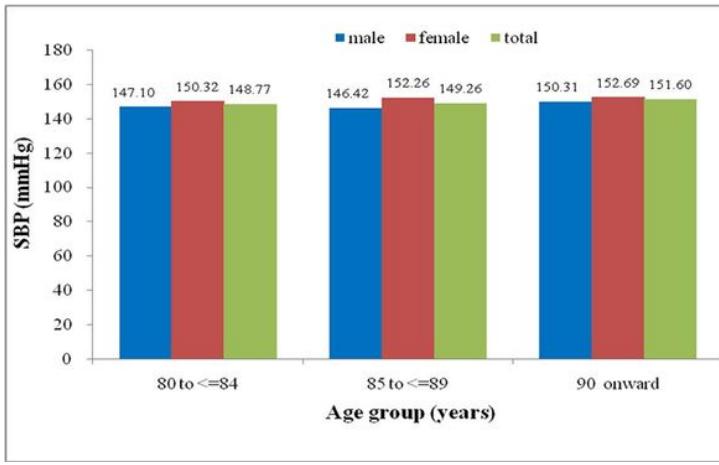


Figure 1-B

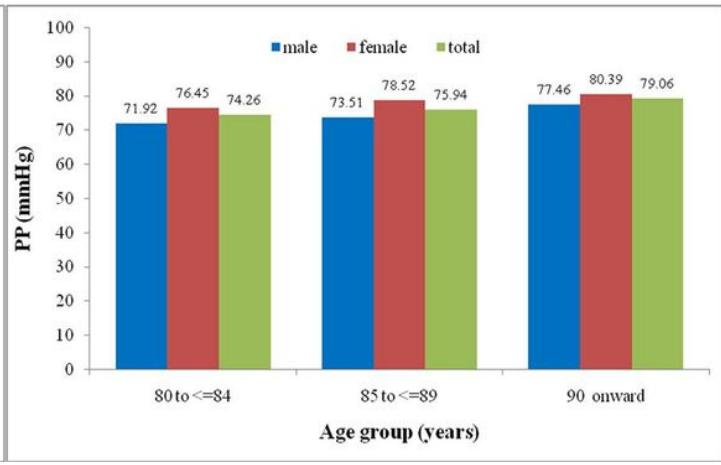


Figure 1

The average blood pressure of different age groups for the Qiang population aged  $\geq 20$  years. (A) Average SBP; (B) average DBP.

Figure 2

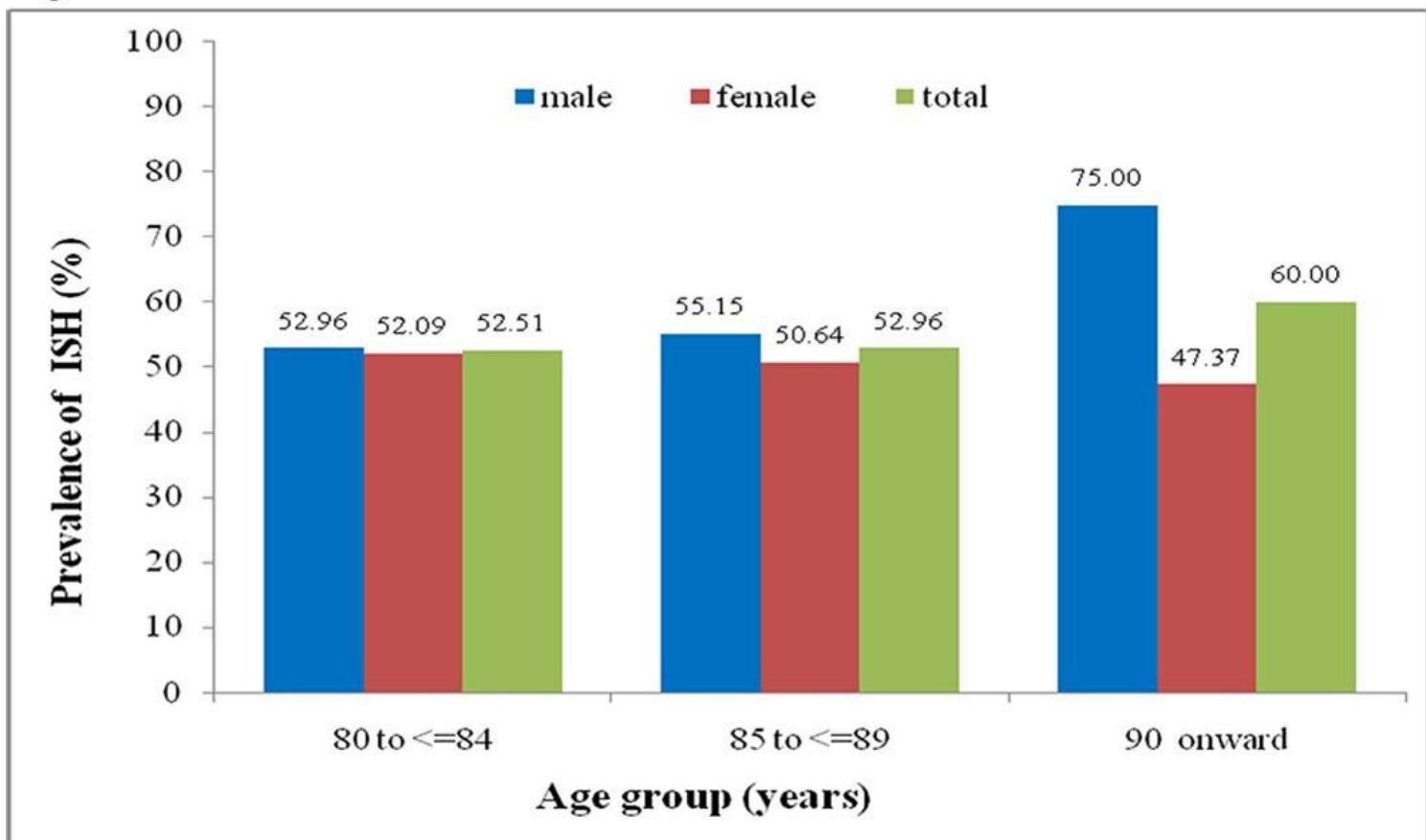


Figure 2

Hypertension prevalence of different age groups for the Qiang population aged  $\geq 20$  years. (A) Prevalence trend test: Male:  $Z = 12.3$ ,  $P < 0.01$ ; Female:  $Z = 12.6$ ,  $P < 0.01$  (B) Prevalence trend test: Urban:  $Z = 20.11$ ,  $P < 0.01$ ; Rural:  $Z = 8.98$ ,  $P < 0.01$