



Prevalence of metabolic syndrome and its influencing factors among the Chinese adults: The China Health and Nutrition Survey in 2009

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ABSTRACT

Objective. We aimed to estimate the up-to-date prevalence of metabolic syndrome (MS) and its influencing factors among the Chinese adults.

Methods. Data were obtained from the China Health and Nutrition Survey conducted in 2009, which was a cross-sectional and partially nationally representative study including a total of 7488 Chinese adults (age ≥ 18 years).

Results. The overall age-standardized prevalence estimates of the MS were 21.3% (95% confidence interval (CI): 20.4%–22.2%), 18.2% (95%CI: 17.3%–19.1%) and 10.5% (95%CI: 9.8%–11.2%) based on definitions of revised NCEP ATPIII, IDF and CDS criteria, respectively. Individuals who were women (compared to men: odds ratio [OR] = 1.37, 95% CI = 1.16–1.61), 40 years or older (compared to less than 40 years old: OR = 2.82, 95%CI = 2.37–3.34 for 40–59 years; OR = 4.41, 95%CI = 3.68–5.29 for 60 years or older), overweight/obese (compared to normal weight: OR = 4.32, 95%CI = 3.77–4.95 for overweight; OR = 11.24, 95%CI = 9.53–13.26 for obese), and living in urban area (compared to living in rural area: OR = 1.27, 95%CI = 1.12–1.43) were more likely to have a higher prevalence estimate of MS. In addition, frequency of alcohol consumption and cigarette intake were also found to be significantly associated with probability of MS.

Conclusions. Our results suggest an urgent need to develop national strategies for the prevention, detection, treatment and control of obesity and MS in China.

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Introduction

Metabolic syndrome (MS) is becoming a major public health issue worldwide (Kassi et al., 2011). MS is characterized by a cluster of metabolic risk factors including central obesity, elevated blood pressure, dysglycemia, high triglyceride levels and low high-density lipoprotein cholesterol levels. Many evidences have suggested that MS is associated with increased risk of cardiovascular disease (CVD) (Scuteri et al., 2005), type 2 diabetes (T2D) (Wannamethee et al., 2005) and all cause-mortality (Ford, 2004). In the past few years, several expert groups have proposed several diagnostic criteria of MS including the World

Health Organization criteria in 1998 (Alberti and Zimmet, 1998), the US Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) (2002), and the International Diabetes Federation (IDF) criteria in 2005 (Alberti et al., 2006), as well as the AHA/NHLBI statement in 2005 (Grundey et al., 2005) and the joint interim statement (JIS) in 2009 (Alberti et al., 2009). These criteria generally share the similar components although they vary somewhat in some specific elements. For example, the components of the revised NCEP ATPIII and IDF criteria are the same but IDF requires central obesity as one obligatory component. The CDS used body mass index (BMI) rather than waist circumference (WC) as one index to define obesity and the cut-offs for other components are different from those in the revised NCEP ATPIII and IDF criteria except for the cut-off of triglycerides.

China is currently experiencing rapid economic, social and cultural changes, including accelerated pace of nutrition transition and remarkable changes in people's lifestyles that may contribute to greatly increased burden of chronic diseases. MS, as a cluster of cardio-metabolic risk factors, is related to chronic diseases. Understanding the MS prevalence in the national level is important to develop the effective programs and strategies to prevent and control MS. However, little is known about the recent prevalence of MS in China.

Abbreviations: AHA/NHLBI, American Heart Association/National Heart, Lung, and Blood Institute; NCEP ATPIII, National Cholesterol Education Program, Adult Treatment Panel III; CHNS, China Health and Nutrition Surveys; CI, confidence interval; CVD, cardiovascular disease; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; IDF, International Diabetes Federation; JIS, joint interim statement; MS, metabolic syndrome; OR, odds ratio; SBP, systolic blood pressure; TG, triglycerides; T2D, type 2 diabetes; WC, waist circumference.

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In this study, data from the China Health and Nutrition Surveys (CHNS) in 2009 (Popkin et al., 2010), a partially nationally representative cross-sectional health and nutrition survey in China, were used to describe the recent prevalence of MS by three definitions (revised NCEP ATPIII, IDF and Chinese Diabetes Society (CDS) criteria), and to examine MS related influencing factors.

Methods

Study design and subjects

The CHNS is a large-scale, partially nationally representative, and successive cross-sectional survey that was designed to explore how the health and nutritional status of the Chinese population has been affected by its social and economic changes. A multistage, random cluster process was used to draw study sample from nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou). The recruitment strategies of the participants have been described elsewhere (Popkin et al., 2010). The questionnaire information includes socioeconomic factors and other related health, nutritional, and demographic measures. Fasting blood samples were collected for the first time in 2009. A total of 10,645 individuals aged 18 years or older were potential eligible in this study. However, 3157 persons were excluded since they did not provide fasting blood or anthropometry data such as weight, height, WC, systolic blood pressure (SBP) or diastolic blood pressure (DBP). At last, 7488 participants were included in the final data analysis. All participants provided informed consent and the study was approved by institutional review board from the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Food Safety, China Center for Disease Control and Prevention.

Measurements

Weight was measured to the nearest 0.1 kg with lightweight clothing on a calibrated beam scale and height was measured to the nearest 0.1 cm without shoes using a portable stadiometer. BMI was calculated as weight in kilograms divided by the square of height in meters. WC was measured at a point midway between the lowest rib and the iliac crest in a horizontal plane using non-elastic tape. Height, weight and WC were measured by trained examiners following a standard protocol from the World Health (WHO, 1995). BP was measured by trained examiners using a mercury sphygmomanometer according to a standard protocol (Chobanian et al., 2003). Measures were collected in triplicate after a 10-min seated rest and the last two of three readings were averaged as the BP values.

Following a 12 hour overnight fast, blood was collected by venipuncture and tested immediately for glucose. Plasma and serum samples were then frozen, and stored at -86°C for later laboratory analysis. All samples were analyzed in a national central lab in Beijing (medical laboratory accreditation certificate ISO 15189:2007) with strict quality control. Fasting plasma glucose was measured with the GOD-PAP method (Randox Laboratories Ltd., UK); high-density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were both measured using glycerol-phosphate oxidase method, and the polyethylene glycol (PEG)-modified enzyme method, respectively, by determiner reagents (Kyowa Medex Co., Ltd., Tokyo, Japan). All lipid measures were on the Hitachi 7600 automated analyzer (Hitachi Inc., Tokyo, Japan) (Yan et al., 2012).

Definitions of MS

In the present study, we used three definitions to define MS in order to make our results more comparable with those using different definitions in other studies. They are the revised NCEP ATPIII criteria for Asians (the American Heart Association and the National Heart, Lung, and Blood Institute (AHA/NHLBI) revised in 2005 (Grundty et al., 2005), the same as the joint interim statement in 2009 (Alberti et al., 2009)), IDF criteria for Asians (Alberti et al., 2006) and CDS (Metabolic syndrome study cooperation group of Chinese diabetes society, 2004) criteria. The detailed information on three criteria was listed in Table 1.

Definitions of potential influencing factors

Overweight and general obesity were defined by WHO suggestions for Chinese (overweight: BMI $25\text{--}27.49\text{ kg/m}^2$; general obesity: BMI $\geq 27.5\text{ kg/m}^2$) (WHO Expert Consultation, 2004). For alcohol consumption, individuals were asked two questions: "Have you consumed alcohol during the past year (yes, no)?" and "What was the frequency of alcohol intake (for individuals who answered 'yes')?" For cigarette smoking, individuals were asked two questions: "What is your smoking status now (never, former, and current)?" and "How many cigarettes do you consume per day now (for individuals who answered 'current')?". Other potential influencing factors included sex (men/women), age group (18–39 years, 40–59 years, and ≥ 60 years), and residence (rural/urban).

Statistical analysis

SPSS version 13.0 (SPSS Inc., Chicago, Illinois) was used for data analysis. Continuous variable was expressed as mean \pm SD and the Student *t* test was used to examine the difference between two groups. The categorical variable was expressed as percentage and the Chi-square test was used to examine the difference between two groups. The prevalence of MS was standardized to the age distribution of the China census population in 2000. Multiple logistic regression analysis was performed to identify influencing factors for MS defined by the revised NCEP ATPIII criteria for Asians. The potential influencing factors included sex, age, residential area, BMI, alcohol consumption and smoking. The reported *p*-value was two-tailed, and $p < 0.05$ was considered to be statistically significant.

Results

Characteristics of the study population

Table 2 shows the characteristics of the total study population ($n = 7488$) by sex. There was no significant difference in mean age and BMI, and distribution of general obesity, and low HDL-C using CDS criteria between two sex groups (All $p > 0.05$). However, significant difference was found for mean WC, SBP, DBP, TG, HDL-C and fasting plasma glucose, and distribution of central obesity, high BP, high TG and low HDL-C using NCEP ATPIII criteria (All $p < 0.001$, which were still statistically significant after correction for multiple testing [$p\text{-value} = 0.05/17 = 0.0029$ using Bonferroni correction]). The most frequent individual component in individuals with MS was a high BP for men (45.7%) and a high WC for women (56.0%).

Table 1
Definition of the metabolic syndrome.

Risk factors	Revised NCEP ATPIII criteria (Grundty et al., 2005; Alberti et al., 2009)	IDF criteria (Alberti et al., 2006)	CDS criteria (Chinese diabetes society, 2004)
Obesity/central obesity	At least three risk factors Men: WC ≥ 90 cm Women: WC ≥ 80 cm	Central obesity plus 2 or more risk factors Men: WC ≥ 90 cm Women: WC ≥ 80 cm	At least three risk factors BMI $\geq 25\text{ kg/m}^2$
High BP	SBP/DBP $\geq 130/85$ mm Hg or taking anti-hypertensive drugs	SBP/DBP $\geq 130/85$ mm Hg or taking anti-hypertensive drugs	SBP/DBP $\geq 140/90$ mm Hg or taking anti-hypertensive drugs
High fasting plasma glucose	Fasting glucose ≥ 5.6 mmol/L	Fasting glucose ≥ 5.6 mmol/L	Fasting glucose ≥ 6.1 mmol/L
High triglycerides	Triglycerides ≥ 1.7 mmol/L	Triglycerides ≥ 1.7 mmol/L	Triglycerides ≥ 1.7 mmol/L
Low HDL-C	Men: HDL-C < 1.03 mmol/L Women: HDL-C < 1.29 mmol/L	Men: HDL-C < 1.03 mmol/L Women: HDL-C < 1.29 mmol/L	Men: HDL-C < 0.9 mmol/L Women: HDL-C < 1.0 mmol/L

ATPIII, National Cholesterol Education Program—Third Adult Treatment Panel; IDF, International Diabetes Federation; CDS, Chinese Diabetes Society; WC, waist circumference; BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 2
Characteristics of the study population by sex.

	Men	Women
n (%)	3485 (46.5)	4003 (53.5)
Age (years)	51.3 ± 15.2	51.1 ± 15.2
WC (cm)	84.5 ± 10.3	81.6 ± 10.4
BMI (kg/m ²)	23.4 ± 3.4	23.4 ± 3.6
SBP (mm Hg)	126.1 ± 17.7	123.7 ± 20.1
DBP (mm Hg)	81.8 ± 11.1	78.8 ± 11.1
TG (mmol/L)	1.8 ± 1.6	1.6 ± 1.2
HDL-C (mmol/L)	1.4 ± 0.5	1.5 ± 0.5
Fasting plasma glucose (mmol/L)	5.5 ± 1.6	5.3 ± 1.3
Central obesity (WC ≥ 90 cm for men; WC ≥ 80 cm for women, %)	31.2	56.0
General obesity (BMI ≥ 25 kg/m ² , %)	29.6	30.0
High blood pressure (SBP/DBP ≥ 130/85 mm Hg or taking drugs, %)	45.7	38.5
High blood pressure (SBP/DBP ≥ 140/90 mm Hg or taking drugs, %)	30.0	25.3
High fasting plasma glucose (fasting plasma glucose ≥ 5.6 mmol/L, %)	28.6	25.3
High fasting plasma glucose (fasting plasma glucose ≥ 6.1 mmol/L, %)	15.8	13.1
High triglycerides (triglycerides ≥ 1.7 mmol/L, %)	35.2	29.5
Low HDL-C (HDL-C < 1.03 mmol/L for men; HDL-C < 1.29 mmol/L for women, %)	16.7	31.0
Low HDL-C (HDL-C < 0.9 mmol/L for men; HDL-C < 1.0 mmol/L for women, %)	6.8	6.6

Data are expressed as mean ± SD, unless otherwise indicated.

Prevalence of MS

Table 3 shows the prevalence of MS among the Chinese adults by sex and age. Overall, the age-standardized prevalence of MS was 21.3% (95%CI: 20.4%–22.2%), 18.2% (95%CI: 17.3%–19.1%) and 10.5% (95%CI: 9.8%–11.2%) based on definitions of revised NCEP ATPIII, IDF and CDS criteria, respectively. The prevalence of MS increased with age. The age-standardized prevalence of MS was somewhat higher in women than in men using IDF criteria (men: 16.2% (95%CI: 15.0%–17.4%); women: 20.0% (95%CI: 18.8%–21.2%)), but was similar using revised NCEP ATPIII (men: 20.9% (95%CI: 19.5%–22.2%); women: 21.7% (95%CI: 20.4%–23.0%)) or CDS criteria (men: 12.2% (95%CI: 11.1%–13.3%); women: 8.7% (95%CI: 7.8%–9.6%)). Notably, the prevalence of MS increased dramatically in women ≥ 60 years of age regardless of the used definitions.

Influencing factors associated with MS

Table 4 shows the ORs for the influencing factors associated with MS among the Chinese adults. Individuals who were women (men as reference, OR = 1.37, 95%CI = 1.16–1.61), 40 years or older (18–39 years as reference, OR = 2.82, 95%CI = 2.37–3.34 for 40–59 years; OR = 4.41,

95%CI = 3.68–5.29 for 60 years or older), overweight/obese (normal weight as reference, OR = 4.32, 95%CI = 3.77–4.95 for overweight, OR = 11.24, 95%CI = 9.53–13.26 for obese), and living in urban area (rural area as reference, OR = 1.27, 95%CI = 1.12–1.43) were more likely to have a higher prevalence of MS. Although alcohol consumption (yes versus no: OR = 0.93, 95%CI = 0.80–1.08) and smoking (never as reference, OR = 0.97, 95%CI = 0.69–1.35 for the former, OR = 1.04, 95%CI = 0.87–1.23 for the current) were not found to be significantly associated with probability of MS, the frequency of alcohol consumption (compared to <1 time/month, OR = 1.82, 95%CI = 1.21–2.75 for 1–3 times/month; OR = 2.03, 95%CI = 1.35–3.05 for 1–2 times/week; OR = 2.07, 95%CI = 1.31–3.27 for 3–4 times/week; OR = 2.16, 95%CI = 1.45–3.22 for early 1 time/day) and cigarette intake (compared to ≤10 cigarettes/day, OR = 1.33, 95%CI = 1.04–1.71 for ≥11 cigarettes/day) were found to be significantly associated with probability of MS.

Discussion

The present study provided the updated information on the prevalence of MS and its related influencing factors among Chinese adults based on the most recent, partially nationally representative data from

Table 3
Prevalence of metabolic syndrome based on definitions of NCEP ATPIII, IDF and CDS criteria among the Chinese adults.

Age groups (years)	n	Metabolic syndrome (prevalence with 95% confidence interval, %)		
		NCEP ATPIII criteria (Grundey et al., 2005; Alberti et al., 2009)	IDF criteria (Alberti et al., 2006)	CDS criteria (Chinese diabetes society, 2004)
All				
18–39	1841	12.4 (10.9–13.9)	10.6 (9.2–12.0)	6.1 (5.0–7.2)
40–59	3475	29.9 (28.4–31.4)	25.3 (23.8–26.7)	14.2 (13.0–15.4)
≥60	2172	36.7 (34.7–38.7)	31.8 (29.8–33.7)	19.2 (17.5–20.8)
Total (the crude)	7488	27.6 (26.6–28.6)	23.6 (22.6–24.6)	13.6 (12.8–14.4)
Total (the age-standardized)	7488	21.3 (20.3–22.2)	18.2 (17.3–19.1)	10.5 (9.8–11.2)
Men				
18–39	866	15.7 (13.3–18.1)	12.4 (10.2–14.6)	9.7 (7.7–11.7)
40–59	1549	27.8 (25.6–30.0)	20.9 (18.9–22.9)	16.4 (14.5–18.2)
≥60	1025	26.1 (23.4–28.8)	20.7 (18.2–23.2)	15.3 (13.1–17.5)
Subtotal (the crude)	3485	24.3 (22.9–25.7)	18.7 (17.4–20.0)	14.4 (13.2–15.6)
Subtotal (the age-standardized)	3485	20.9 (19.5–22.2)	16.2 (15.0–17.4)	12.2 (11.1–13.3)
Women				
18–39	975	9.5 (7.6–11.3)	9.0 (7.2–10.8)	2.9 (1.8–3.9)
40–59	1881	31.6 (29.5–33.7)	29.1 (27.0–31.1)	12.3 (10.8–13.8)
≥60	1147	46.2 (43.3–49.1)	41.8 (38.9–44.6)	22.7 (20.3–25.1)
Subtotal (the crude)	4003	30.4 (29.0–31.8)	27.8 (26.4–29.2)	13.0 (11.9–14.0)
Subtotal (the age-standardized)	4003	21.7 (20.4–23.0)	20.0 (18.8–21.2)	8.7 (7.8–9.6)

Table 4

Risk factors for metabolic syndrome based on revised NCEP ATPIII criteria among the Chinese adults ($n = 7488$).

Variables	Adjusted OR ^a	95%CI ^a
Sex		
Men	Referent	
Women	1.37	1.16–1.61
Age (years)		
18–39	Referent	
40–59	2.82	2.37–3.34
≥60	4.41	3.68–5.29
Residence		
Rural	Referent	
Urban	1.27	1.12–1.43
Body mass index (kg/m ²)		
<25	Referent	
25–27.49	4.32	3.77–4.95
≥27.5	11.24	9.53–13.26
Alcohol status (during past year)		
No	Referent	
Yes	0.93	0.80–1.08
Frequency of alcohol intake		
<1 time/month	1	
1–3 times/month	1.82	1.21–2.75
1–2 times/week	2.03	1.35–3.05
3–4 times/week	2.07	1.31–3.27
Nearly 1 time/day	2.16	1.45–3.22
Smoking status		
Never	Referent	
Former	0.97	0.69–1.35
Current	1.04	0.87–1.23
Cigarettes per day (current)		
≤10	1	
≥11	1.33	1.04–1.71

OR, odds ratio; CI, confidence interval.

^a Logistic regression model included all the listed exposure variables.

the CHNS. The age-standardized prevalence of MS was very high, with 21.3%, 18.2% and 10.5% based on definitions of revised NCEP ATPIII, IDF and CDS criteria, respectively. High BP was the most frequent component in men and high WC was the most frequent component in women. MS was associated with older age, being a woman, living in urban region and with central obesity. These results suggested that MS is still a serious public burden in China and highlights the urgent need for implementing effective measures to improve the prevention, detection, diagnosis and treatment of MS in China.

In our study, the prevalence of MS in Chinese was similar when using the revised NCEP ATPIII (21.3%) and IDF (18.2%), but they were higher than that defined by CDS criteria (10.5%). That is, the CDS criteria might have underestimated the prevalence of MS in the Chinese population. In 1992, the prevalence of MS using the NCEP ATPIII criteria was reported to be 12.7% in men and 14.2% in women based on the study including 27,739 subjects aged 35–64 years conducted in 11 provinces of China (Further study of risk factors for stroke and coronary heart disease group, 2002). In 2000, the age-standardized prevalence of MS using the NCEP ATPIII criteria for Caucasians was estimated to be 9.8% in men and 17.8% in women from a partially nationally representative sample of 15,540 Chinese adults aged 35–74 years (Gu et al., 2005); based on the same population, the age-standardized prevalence of MS was reported to be 17.7% in men and 29.1% in women by revised NCEP ATPIII criteria, 10.0% in men and 23.3% in women by the IDF criteria (Yang et al., 2007). Generally, the age-standardized prevalence of MS in both men (IDF: 16.2%, revised NCEP ATPIII: 20.0%) and women (IDF: 20.9%, revised NCEP ATPIII: 21.7%) in the present study was higher than that reported in 1992 (Further study of risk factors for stroke and coronary heart disease group, 2002), but was similar with that reported in 2000 (Yang et al., 2007). In addition, data from the 2007–2008 Korea National Health and Nutrition Examination Survey including 7289 adults 19–65 years of age indicated that the prevalence

of MS using the IDF criteria was 15.8% in men and 11.6% in women, which was lower than that of our CHNS data using the IDF criteria (Lim et al., 2012). In the original NCEP ATPIII criteria based on Caucasians, WC > 102 cm in men and > 88 cm in women were used to define central obesity, while in the revised NCEP ATPIII definitions, the ethnic-specific cut-points (WC ≥ 90 cm in men and WC ≥ 80 cm in women) were proposed to identify central obesity in East Asians (Alberti et al., 2009; Grundy et al., 2005). Indeed, evidences have suggested that East Asians have a higher percentage of body fat at a lower BMI than Caucasians (Deurenberg et al., 2002). Thus, it is not surprising that the application of the NCEP ATPIII criteria or the IDF criteria for Caucasians to East Asians would seriously underestimate the population at risk (Tan et al., 2004).

The prevalence of MS in the present study was somewhat higher in women than that in men, which was consistent with previous finding in China (Further study of risk factors for stroke and coronary heart disease group, 2002; Gu et al., 2005; Yang et al., 2007). The great increase in prevalence of MS in women ≥ 60 years of age might be due their postmenopausal status which is associated with increase of central obesity (Kim et al., 2007; Lim et al., 2012). Subjects living in urban area were more likely to have MS than those living in rural area. Economic development and change in dietary pattern might help explain the difference between the two regions. However, further studies are required to identify which lifestyle factors might contribute to the differences. Our results confirmed that obesity as well as overweight were independent influencing factors for MS. In our recent study, we have reported that the prevalence of overweight and obesity increased substantially from 1993 to 2009, and currently 15.7% of the population are overweight and 10.0% are obese (Xi et al., 2012a). Therefore, planning a healthy dietary program, increasing physical activities, and adopting other healthy behaviors and lifestyles would be helpful to maintain the optimal standardized weight, thereby lowering the prevalence of MS. In addition, we found significant association between frequency of smoking and alcohol consumption in MS. These findings were consistent with those from other studies (Cai et al., 2012; Freiberg et al., 2004).

This study has several strengths. Training was conducted for all study staff to ensure standardization of data collection. Vigorous quality assurance and control procedures were employed. This study was, however, subject to several limitations. First, the sample was partially nationally representative, since only nine of China's 31 provinces were included. In addition, the response rate was about 70% because of missing values on fasting blood or anthropometry data. Second, this is a cross-sectional study that does not allow us to draw any causal conclusions. Third, the major impact factors such as dietary habits and physical activity level were not included in the data analyses since they are not inaccessible at present. Fourth, we did not collect the data on whether the participants were taking any medications, but the lipid-lowering, glucose-lowering or blood pressure-lowering drugs may influence the metabolic profile.

In summary, MS is still highly prevalent among Chinese adults regardless of the used criteria, especially in women, elderly subjects, those living in urban regions and obese populations. The high prevalence of MS will further increase the burden of CVD, T2D and related morbidity and mortality. Our results suggest an urgent need for a national MS education program, including improving participants' understanding of MS and related diseases, developing healthy lifestyle (e.g. weight control and more physical activity), to improve the prevention, detection, treatment and control of MS in China, with the ultimate goal to lower the MS-related morbidity and mortality (Xi et al., 2012a; Xi et al., 2012b).

Contributions

Study concept and design: BX. Acquisition of data: DH and YH. Analysis and interpretation of data: BX and DZ. Drafting of the

manuscript: BX. Critical revision of the manuscript for important intellectual content: BX, DH, YH, and DZ.

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