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The concordance of chronic conditions among the household members in Shanghai: a cross-sectional study

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Abstract

Objectives: Members living in the same household usually have some similar behaviors and stay in the same environment. We quantitatively assessed the associations of chronic conditions to investigate the concordance of disease status among the household members in Shanghai, China.

Study Design:

A cross-sectional study.

Setting:

Shanghai, China.

Participants:

Our data was from the fifth Health Service Survey of Shanghai in 2013. 12,002 households with 31,531 residents were selected in this survey by using a three-stage, stratified, random sampling method.

Main outcome measure:

We had chosen five chronic conditions with high prevalence in this survey: hypertension, diabetes, ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity. The generalized estimating equations (GEE) model was used to estimate the associations with adjustment for age, gender, education status, health insurance status, marriage status, smoking, and drinking. Except for all adult household members, we also explored the relationships among dyads of parents and children and spouses.

Results:

A total of 10,198 households with 27,010 adult participants were included in our study. For all household members, we found that there were positive associations between one's chronic conditions and the same disease status of their household members (hypertension: odds ratio (OR) = 1.51, 95% confidence interval (CI) 1.38-1.64; diabetes: OR = 1.68, 95% CI 1.40-2.01; IHD: OR = 5.31, 95% CI 3.56-7.92; CVD: OR = 3.40,

95% CI 1.99-5.80; obesity OR = 3.41, 95% CI 2.34-4.96). The similar associations were also indicated by the results of parents-children and spouses subsets. Moreover, the potential concordance of different chronic conditions was found in pair of hypertension and diabetes.

Conclusion:

Our findings indicated that there were positive associations between the chronic condition status of the household members. This study provided the evidence about the effect of co-residence factor in the prevalence of chronic conditions.

Strength & Limitations:

- This is the first study to estimate the risk of chronic conditions when family members has one or more chronic conditions in China.
- We performed a quantitative estimation of the assoication between one's chronic condition status and their household members, including parents-children and spouses.
- The definition and diagnosis of chronic condition for each participant was based on self-reported records.
- This study was conducted in Shanghai and the results could not represent the situation in other regions of China.
- Our study could not provide the estimation about the risk of new chronic condition in health household members and find out some significant risk factors.

Key words: chronic conditions; household; concordance

Background

During the past three decades, China had experienced rapid social, economic and health services development[1 2]. The life expectancy have increased, lifestyles have changed, health care have become more accessible, and health insurance coverage have increased. For these remarkable growths, the burden of disease for country and residents have shifted from some infectious diseases to non-communicable chronic conditions[2-4]. Some researches had shown the prevalence of hypertension increased from 5.11% in 1959 to 17.65% in 2002, and the prevalence of type 2 diabetes mellitus increased from 1% in 1980 to 9.7% in 2008[5-7]. Non-communicable chronic conditions were also main burden of diseases for disability-adjusted life-years (DALYs), high systolic blood pressure, high fasting plasma glucose, and high body mass index were the 1st, 2nd and 4th ranked risk factor for globe DALYs in 2015, recepectively. While, in 1990, the ranks of these three diseases were 3rd, 10th and 13th, recepectively[8]. Shanghai is a typical city in China, which can well represent the direction of economic and healthy development in China. Noteworthily, the problem of aging in Shanghai is particularly serious. Moreover, this would bring about the new challenges of healthcare for our society and government[9].

For the problem of chronic conditions, the improvement of healthcare and innovation of new effective medical treatment will be very important. Additionally, detecting the risk factors of chronic conditions incidence and finding out the high-risk population are also the effective way to control the prevalence of chronic conditions. To look for the risk factors, many researches had focus on the personal lifestyles which are associated with risk of chronic conditions, such as smoking, drinking, exercise, diet and so on[10-13]. Some genetic mechanisms are also considered as the risk factor of chronic conditions[14 15]. The household environment, which integrate the lifestyles, genetic mechanisms and environmental factors, would be an important study direction on

controlling the prevalence of chronic conditions[16].

Based on the fifth Health Service Survey of Shanghai, which was the extension of China's National Health Service Survey (NHSS) in 2013, the prevalence rate was 27.24% for hypertension and 7.05% for diabetes among 29,269 people aged 15 or older. For hypertension, the results of survey indicate 6,096 households (50.79%) of 12,002 families had at least one person with hypertension, and 1,733 households (28.43%) of these 6,096 households had at least two persons with disease. This result had shown that there might be households clustering in prevalence of chronic conditions. To test and explore the hypothesis that whether one's chronic conditions are related to the others with chronic conditions living in the same household, we conducted the research and analyses based on the fifth Health Service Survey of Shanghai. We chose five chronic conditions with high prevalence: hypertension, diabetes, Ischemic heart disease (IHD), cerebrovascular disease (CVD), obesity. The chronic conditions associations would be detected among all household members, dyads of parents and children, and spouses, respectively.

Methods

Data source

The data for this study was from the fifth Health Service Survey of Shanghai in 2013. This survey was organized and conducted by the Shanghai Municipal Commission Health and Family Planning, and was the extension of NHSS. From 1993 to 2013, the NHSS has been conducted for five times (every five years), and is a cross-sectional survey study[17]. The sampling method and quality assurance measures used in Shanghai survey were consistent with the national sampling approach and principle[18]. The fifth Health Service Survey of Shanghai cover all of the 17 districts in Shanghai, and a three-stage, stratified, random sampling method was adopted. First stage, 100

towns/townships were selected randomly from all these 17 districts. Second stage, one thousand villages/communities were sampled randomly from these selected towns/townships. Third stage, about 12,000 households were identified randomly.

A face-to-face interview approach using structured household questionnaire, which was developed by the National Commission Health and Family Planning of China, was conducted for each household. The questionnaire contained the general information of household, the demographic characteristics of residents, the relationship of household members, self-reported illness and injury, outpatient and inpatient information.

To ensure the quality of this survey, some quality assurance measures were applied during the process of data collection. Logic errors would be checked among the data by survey constitutors. If there were logic errors, the investigators would contact the household members and verify the relevant information. The accuracy of data information were assessed by revisit-approach. The investigators revisited 5% of the sampled households and collected ten key questions to check the consistency of the information recorded. The consistency rate between these two visits was near to 99 %. Additionally, the Myer's Blended index was 7.39, indicating that there was non-existence of age preference in this survey[19 20]. Finally, this survey collected the information of 12,002 households and 31,531 respondents. And in our study, we included the households with at least two adults who aged 18 or older.

Five chronic conditions

Hypertension: Hypertension for every resident was indicated based on the question in the questionnaire "Have you ever been told by a doctor that you have hypertension". The one who chose "YES" was considered to have hypertension.

Diabetes: Diabetes for every resident was indicated based on the question in the questionnaire "Have you ever been told by a doctor that you have diabetes". The one

who chose "YES" was considered to have diabetes.

IHD: The questionnaire will record all of the chronic diseases for every resident, and these chronic diseases would been encoded in accordance with the disease coding list of the NHSS. IHD included angina pectoris (061), myocardial infarction (062), and other ischemic heart disease (063).

CVD: This chronic condition would be indicated according to the disease coding list of the NHSS: cerebrovascular disease (067).

Obesity: Body mass index (BMI) would be calculated for every resident by height and weight. Obesity was indicated by the World Health Organization (WHO) International BMI categories (BMI $\geq$ 30 kg/m^2)[21].

Covariates

Some socio-demographic characteristics would be included in our analyses as covariates. Age (continuously specified in years), education status (illiteracy/primary, secondary or college), health insurance status (yes or no), smoking (yes or no), drinking (yes or no). Except the analyses of spouse subset, gender (male or female) and marriage status (married, unmarried, divorced or widowed) was also included as a covariate.

Statistical analyses

Before statistical analyses, we would identify whether each participant live in the household with the given chronic conditions. For example, if any other resident (excluding self) had the given chronic conditions, the indicator of household situation for he/she was "YES". Then the generalized estimating equations (GEE) model with logit link would be used to find out the relationship between one's chronic conditions and the others with chronic conditions living in the same household. The odds ratio (OR) and 95% confidence interval (CI) were estimated by GEE model to indicate the

association between any chronic condition or each given chronic condition of individual with the same condition of household member (e.g., the relationship between hypertension and others household members with hypertension). And the association of different chronic condition would also be assessed (e.g., the relationship between hypertension and others household members with diabetes).

We would estimate these associations in three different household scenes: all household members, dyads of parents and children, and spouses. For the first scene, we included all household members who aged 18 or older, and the definition of exposure was shown at the beginning of this section. For the second scene, only adult children would be included in analyses, and the chronic conditions of each of their parents were considered as exposure. If the chronic conditions for their parents were not available, this record should be excluded. And for the third scene, we defined the chronic condition of wife as the outcome and the chronic condition of husband as the exposure. The subgroup analyses would be conducted in the first scene according to two pre-defined stratification factors: sex (male or female), education (illiteracy/primary, secondary, and college).

Adjusted models and unadjusted models were both used to estimate the relationship in three household scenes. The adjusted models included age, gender, health insurance status, education status, marriage status, drinking and smoking (gender and marriage status were excluded in the third scene), and the final conclusion was based on the results of the adjusted models. The results of unadjusted models would be obtained in supplementary information. The choice of the working correlation matrix for GEE model was based on the quasi-likelihood information criterion (QIC) index (select the matrix with the smallest QIC index)[22]. We did not conducted any statistical model to deal with the missing data because of low missing data rate. The observation with missing data would be excluded from the final analyses. All data management and

statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC). All reported p values were two-sided and p value < 0.05 was regarded as statistically significant. This study is reported according to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines (supplementary S1), and all analyses were conducted on the basis of the statistical analysis plan (supplementary S2).

Patient and public involvement

This study is a cross-sectional questionnaire survey and no patient involved.

Results

A total of 10,198 households (27,010 participants) with at least two adults who aged 18 or older were included in our study from the data of the fifth Health Service Survey of Shanghai in 2013. For the second scene, there were 5,489 available records of dyads of parents and children, and 7,844 records of spouses had been analyzed in the third scene. The detail information was shown in flowchart (Fig. 1). Table 1 has shown the details of socio-demographic characteristics. The mean age of all included participants was 52.63 years, and 31.34% (n=8,467) had at least one chronic condition. However, the children participants of parents-children subset were younger (36.01 years), and the prevalence rates of chronic conditions were much lower (the rate of chronic conditions was 11.89%).

All household members

For the first scene, the results indicated that the chronic condition of participant was associated with the others with the same chronic condition living in the same household (the diagonal of Table 2): any chronic condition (OR =1.46, 95% CI: 1.34-1.58), hypertension (OR =1.51, 95% CI: 1.38-1.64), diabetes (OR = 1.68, 95% CI: 1.40-2.01), IHD (OR = 5.31, 95% CI: 3.56-7.92), CVD (OR = 3.40, 95% CI: 1.99-5.80), and

obesity (OR = 3.41, 95% CI: 2.34-4.96). The results also revealed that there were significantly positive associations for some different chronic conditions (diabetes and hypertension, diabetes and obesity). The OR was 1.29 (95% CI: 1.17-1.42) for diabetes to hypertension and 1.23 (95% CI: 1.11-1.36) for hypertension to diabetes. The OR was 1.45 (95% CI: 1.16-1.82) for diabetes to obesity and 1.36 (95% CI: 1.09-1.70) for obesity to diabetes. More detail information was shown in Table 2, and the results of unadjusted GEE models were listed in the Table S1.

In subgroup analysis, we found the similar association for the sex subgroups and education level subgroups (Fig.2, Fig.3 and Table S2). However, the significant relationship was not found in analyses of diabetes and IHD in subgroup of college education.

Dyads of parents and children

We did not conduct the analyses about IHD and CVD in this household scene for the reason of low prevalence rate (0.2% for IHD, and 0.15% for CVD). Table 3 listed the results of adjusted GEE models for dyads of parents and children. The positive associations were observed in all of the same chronic condition pairs: any chronic condition (OR = 5.13, 95% CI: 4.20-6.28), hypertension (OR = 6.29, 95% CI: 4.92-8.05), diabetes (OR = 11.56, 95% CI: 7.88-16.98), and obesity (OR = 13.79, 95% CI: 8.50-22.38). For different chronic conditions, the children with diabetes and obesity were associated with parents with hypertension (OR was 2.40 for diabetes, and OR was 1.69 for obesity). And the results also indicated that hypertension status of children was associated with the diabetes status of their parents (OR = 1.61). The results of unadjusted GEE models for the second household scene were listed in the Table S3.

Spouses

The results of the spouses scene were shown in the Table 4. Agreeing with the results shown in the above two scenes, the positive associations were also observed in the same

chronic condition pairs for spouses: any chronic condition (OR = 1.58, 95% CI: 1.41-1.77), hypertension (OR = 1.63, 95% CI: 1.45-1.84), diabetes (OR = 1.57, 95% CI: 1.21-2.03), IHD (OR = 6.58, 95% CI: 3.78-11.43), CVD (OR = 3.62, 95% CI: 1.86-7.07), and obesity (OR = 5.10, 95% CI: 2.93-8.88). The wives with diabetes and IHD were associated with the hypertension status of their husbands (OR was 1.46 for diabetes, and OR was 1.60 for IHD). And the relationship between the hypertension status of wives and the diabetes status of husbands was also indicated (OR = 1.29). The information of unadjusted GEE models could be available in Table S4.

Discussion

In China, Shanghai has the heaviest burden of noncommunicable diseases, because it has the largest population and the largest ageing population[23]. Our study had conducted in-depth analyses about the association of five pre-selected chronic conditions status between the household members in Shanghai, China. Using the data of the fifth Health Service Survey, we found that the participants who live with the household members with chronic conditions were associated with 46% higher OR of having one or more chronic condition. For these five chronic conditions, the above relationship was observed in each same chronic condition. We also found the similar associations in dyads of parents and children scene and spouses scene. These results were consistent with some other research results[16 24-26]. Additionally, the results had revealed that there might be potential associations between the different chronic conditions, such as hypertension and diabetes.

We chose five chronic conditions (hypertension, diabetes, IHD, CVD, and obesity) as the target diseases of our study, because these five chronic conditions were the most prevalent in this health service survey. Based on the current knowledge, the incidence of the chronic conditions is the result of a combination of multiple factors. The main

point of our study was to explore the effect of the co-residence factor on the prevalence and incident of chronic conditions. The members of the same household would live in the same environment, and might have the similar behaviors as well. In addition, some of them would have genetic associations (such as patients and children, brothers and sisters). Therefore, the co-residence factor could be considered as the combination of multiple factors. Some researches had reported the association between the family health history and risk of disease[27-29]. The co-residence factor could partially reflect the family health history, but also represent some common environment and behavior factors caused by living together. Our study indicated the positive associations between the adults with chronic condition and the household members with the same condition. According to the results of all household members, we found that the ORs for IHD and CVD were large and the 95% CI of the corresponding ORs was wider. The reason for such results might be that the prevalence rate of IHD and CVD were only 1.68% and 1.38%, respectively. And low prevalence rate would reduce the accuracy of statistical model estimation. However, the results of both the adjusted GEE model and the crude GEE model showed the positive associations for these two chronic conditions.

In order to further explore the effect of co-residence factor on the chronic conditions, we conducted analyses in two scenes. For dyads of parents and children, we considered that there were significant genetic factors besides some environment and behavior factors. And the effect of genetic factors would be excluded in the analyses of spouses. The positive associations, which were similar to the results of all household members, were found in these two scenes, and the results were consistent with some previous studies[24-26 30 31]. The results of analyses in these two special sub-population might show the effect of genetic factors and mere co-residence factor without genetic ties in the relationships that we were interested in. Moreover, the adjusted ORs in analyses about dyads of parents and children were much larger (e.g. OR is 6.12 for hypertension

association). However, we could make a simple conclusion that the effect of genetic factors was much more important. Because some chronic conditions would be age-related diseases and the prevalence rates of adult children in this health service survey were low. For example, the prevalence rate of hypertension for adult children was only 8.86% (the mean of age was 39.16), and prevalence rate for those whose parents had no hypertension was much lower (only 3.34%, the mean of age was 34.36). Based on this consideration, we included the age covariate into the adjusted model. Therefore, these results could reflect the associations of chronic condition status between children and their parents though the ORs might be high.

In addition to explore the association of the same chronic condition between participants and their household members, the results of different chronic conditions indicated that there might be positive associations between hypertension and diabetes. This kind of association was consistent in all three scenes. The mechanisms and pathways could not be concluded in our study, but several previous studies might provide some hypotheses. The hypertension and diabetes are the syndromes of metabolic syndrome (MetS). Some risk factors for MetS, such as lifestyle, diet, family disease history, environment, might be the co-factors for the prevalence of hypertension and diabetes[32-34]. However, the exact mechanisms should need further investigation.

The main purpose of our study was to indicate the associations of chronic conditions among the household members. Although we did not provide some specific risk factors for the prevalence of chronic conditions, the quantitative assessment of the associations had shown the effect of co-residence factor for the disease status among the household members. According to our study, we suggested that the residents, whose household members had some chronic conditions, should pay more attention to their health status. Health education about chronic disease and change of some potential unhealthy behaviors might reduce the prevalence rate of chronic conditions for these residents.

Moreover, regular health examination (e.g. measurement of blood pressure and weight) would be helpful for residents to monitor their own health status. Shanghai as the biggest and most developed city in China lends the development trend. Some investigators had indicated that Shanghai Chronic Disease Self-Management Program (CDSMP), which is the most widely accepted self-management patient education programme worldwide, could improved participants' health behaviour, self-efficacy, and health status[23]. Maybe this program could be modified and acceptable to the health residents whose household members have chronic conditions. Moreover, the similar phenomenon that concordance of chronic conditions among the household members would be also paid attention to in other regions of China, and the relevant solution should be found out advanced. These would be beneficial for controlling the prevalence rate of chronic conditions and reducing the disease burden for country and residents.

Our study had several potential limitations. First, the definition and diagnosis of chronic condition for each participant was based on self-reported records. There might be the potential risk of underreporting and misreporting. However, this survey was part of the NHSS and every investigator had undergone rigorous and formal training. Previous researchers have shown the agreement between biomedical and self-reported measurements of some chronic conditions in a Chinese national community sample[35]. Therefore, the records of these five chronic conditions would be reliable. Second, this study was conducted in Shanghai and the results could not represent the situation in other regions of China. Nevertheless, it could cause people and health management department to pay attention to this problem. Third, our study could not provide the estimation about the risk of new chronic condition in health household members and find out some significant risk factors. We only indicated the phenomenon that there were associations for the prevalence of chronic conditions in the household level. These results suggested that we'd better pay attention to the health status of the health

residents in the households with members with chronic conditions. Fourth, this study is a cross-sectional survey study, and several potential bias, such as recall bias, confounding bias and reporting bias, might not be completely avoided. For the confounding bias, we conducted the analyses by the adjusted GEE models with some socio-demographic covariates.

Conclusions

In conclusion, our study had indicated one's chronic condition status was associated with the status of their household members in the Shanghai, China. The results of parents-children and spouses subsets were consisted with the analyses of all household members. Additionally, analyses about different chronic conditions showed that there might be positive associations between hypertension and diabetes. The mechanisms about these associations should be investigated by further research. However, the evidence about the effect of co-residence factor in some chronic conditions would suggest that people should pay more attention to their health status, especially those whose household members have chronic conditions. That might reduce the prevalence and increase the early detection rate about some chronic conditions.

List of abbreviations

IHD = ischemic heart disease

CVD = cerebrovascular disease

GEE = generalized estimating equations

OR = odds ratio

CI = confidence interval

DALYs = disability-adjusted life-years

NHSS = National Health Service Survey

BMI = body mass index

WHO = World Health Organization

QIC = quasi-likelihood information criterion

STROBE = Strengthening the Reporting of Observational studies in Epidemiology

MetS = metabolic syndrome

CDSMP = Chronic Disease Self-Management Program

Declarations

Ethics approval and consent to participate

This cross-sectional questionnaire survey was organized by the Shanghai Municipal Commission Health and Family Planning. As we knew, this survey didn't contain any treatment, blood drawing or others intervention which might influence the health of participators. Informed consent was obtained by surveyors prior to data collection and personal information was with strict conservation during our analysis process. Thus no ethical approval is required for our study.

Consent for publication

We give my consent for information about myself/my child or ward/my relative (circle as appropriate) to be published in *BMC Public Health.*

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 of interest

The authors declare that they have no competing interests.

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Authors' contribution

Dr. Yingyi Qing ,Dr. Yibin Guo and Prof. Jia He designed this study. Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Cheng Wu analysized the data. Prof. Qian He and Dr. Xinji Zhang checked the statistical analysis. Dr. Yibin Guo and Dr. Yingyi Qin wrote the manuscript. Prof. Jia He revised this manuscript.

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Key points:

- Little study was studied on the topic of concordance of chronic conditions among the household.
- This is the first study to estimate the risk of chronic conditions when family members has one or more chronic conditions in China.
- We performed a quantitative estimation of the assoication between one's chronic condition status and their household members, including parents-children and spouses.
- We suggested that the residents, whose household members had some chronic conditions, should pay more attention to their health status.

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Figure legends

Figure 1 The flow chart of participates selection of the three scenes analysis

Figure 2 The forest plot of five chronic conditions subgroup analysis categorized by gender. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

Figure 3 The forest plot of five chronic conditions subgroup analysis categorized by education status. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

Table 1 Socio-demographic characteristics of participants

Characteristic	All household members	Children[a]	Wives[b]
No. of households	10,198	4,865	7,211
No. of participates	27,014	5,493	7,845
Age, years, mean (SD)	52.63(17.06)	36.01(12.18)	54.01(13.85)
Male, n (%)	13,182(48.8)	3,273(59.58)	-
Education status, n (%)[c,e]			
Illieracy/Primary	5,801(21.47)	334(6.08)	2,191(27.93)
Secondary	14,484(53.62)	2,481(45.17)	4,551(58.01)
Collage	6,727(24.9)	2,678(48.75)	1,102(14.05)
Marriage status, n (%)[f]			
Unmarried	3,124(11.56)	2,286(41.62)	-
Married	22,116(81.87)	2,924(53.23)	-
Divorced or widowed	1,772(6.56)	283(5.15)	-
Insurance, n (%)	26,011(96.29)	5,247(95.52)	7,575(96.56)
Drinking, n (%)	5,157(19.09)	944(17.19)	222(2.83)
Smoking, n (%)	6,392(23.66)	1,460(26.58)	166(2.12)
Chronic conditions, n (%)			
Any chronic conditions[d]	8,467(31.34)	653(11.89)	2,414(30.77)
Hypertension	7,245(26.82)	480(8.74)	2,102(26.79)
Diabetes	1,875(6.94)	110(2)	498(6.35)
IHD	455(1.68)	11(0.2)	117(1.49)
CVD	372(1.38)	8(0.15)	106(1.35)
Obesity	631(2.34)	128(2.33)	156(1.99)

Notes:

a The characteristics of children in parents-children subset.

b The characteristics of wives in spouses subset.

c "Illieracy/Primary" in education status means the education years were from 0 to 5 years, "secondary" means the education years were from 6 to 12 years, and "collage" means the education years of residents were higher than 12 years including undergraduate and graduate degrees.

d The participants had at least one chronic condition.

IHD: Ischemic Heart Disease; CVD: Cerebrovascular Disease.

e There were 2 participates missing in education status in data set.

f There were 2 participates missing in marriage status in data set.

Table 2 The adjusted associations between one's chronic conditions and the disease status of their own household members - Scene 1 (N = 27,010)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	1.46 (1.34-1.58)	<0.0001	1.46 (1.34-1.58)	<0.0001	1.30 (1.17-1.45)	<0.0001	1.23 (1.00-1.51)	0.0467	1.01 (0.81-1.26)	0.9269	1.29 (1.09-1.53)	0.0034
Hypertension	1.45 (1.34-1.57)	<0.0001	1.51 (1.38-1.64)	<0.0001	1.23 (1.11-1.36)	<0.0001	1.18 (0.97-1.45)	0.0951	0.87 (0.70-1.08)	0.1930	1.09 (0.93-1.29)	0.2846
Diabetes	1.38 (1.25-1.52)	<0.0001	1.29 (1.17-1.42)	<0.0001	1.68 (1.40-2.01)	<0.0001	1.06 (0.79-1.42)	0.6846	1.10 (0.80-1.50)	0.5632	1.45 (1.16-1.82)	0.0012
IHD	1.08 (0.90-1.30)	0.3911	1.07 (0.88-1.29)	0.5015	1.00 (0.75-1.33)	0.9949	5.31 (3.56-7.92)	<0.0001	1.46 (0.90-2.35)	0.1224	0.90 (0.54-1.50)	0.6846
CVD	0.95 (0.77-1.16)	0.5856	0.81 (0.66-1.00)	0.0526	1.03 (0.76-1.40)	0.8473	1.51 (0.93-2.43)	0.0951	3.40 (1.99-5.80)	<0.0001	0.60 (0.31-1.15)	0.1251
Obesity	1.40 (1.18-1.66)	0.0001	1.14 (0.97-1.35)	0.1002	1.36 (1.09-1.70)	0.0076	0.86 (0.51-1.45)	0.5663	0.58 (0.29-1.15)	0.1172	3.41 (2.34-4.96)	<0.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, marriage status, drinking and smoking.

Table 3 The adjusted associations of chronic conditions between children and their own parents - Scene 2 (N = 5,489 dyads)

Exposure:	Any chronic conditions		Hypertension		Diabetes		Obesity	
chronic condition status of parents	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	5.13(4.20-6.28)	<.0001	5.59(4.35-7.18)	<.0001	4.66(2.90-7.48)	<.0001	3.02(2.07-4.42)	<.0001
Hypertension	3.93(3.25-4.75)	<.0001	6.29(4.92-8.05)	<.0001	2.40(1.61-3.57)	<.0001	1.69(1.17-2.44)	0.0056
Diabetes	2.17(1.67-2.83)	<.0001	1.61(1.16-2.25)	0.0047	11.56(7.88-16.98)	<.0001	1.51(0.88-2.57)	0.1346
Obesity	5.23(3.24-8.45)	<.0001	1.00(0.45-2.21)	0.9951	2.47(0.95-6.42)	0.0639	13.79(8.50-22.38)	<.0001

Note:

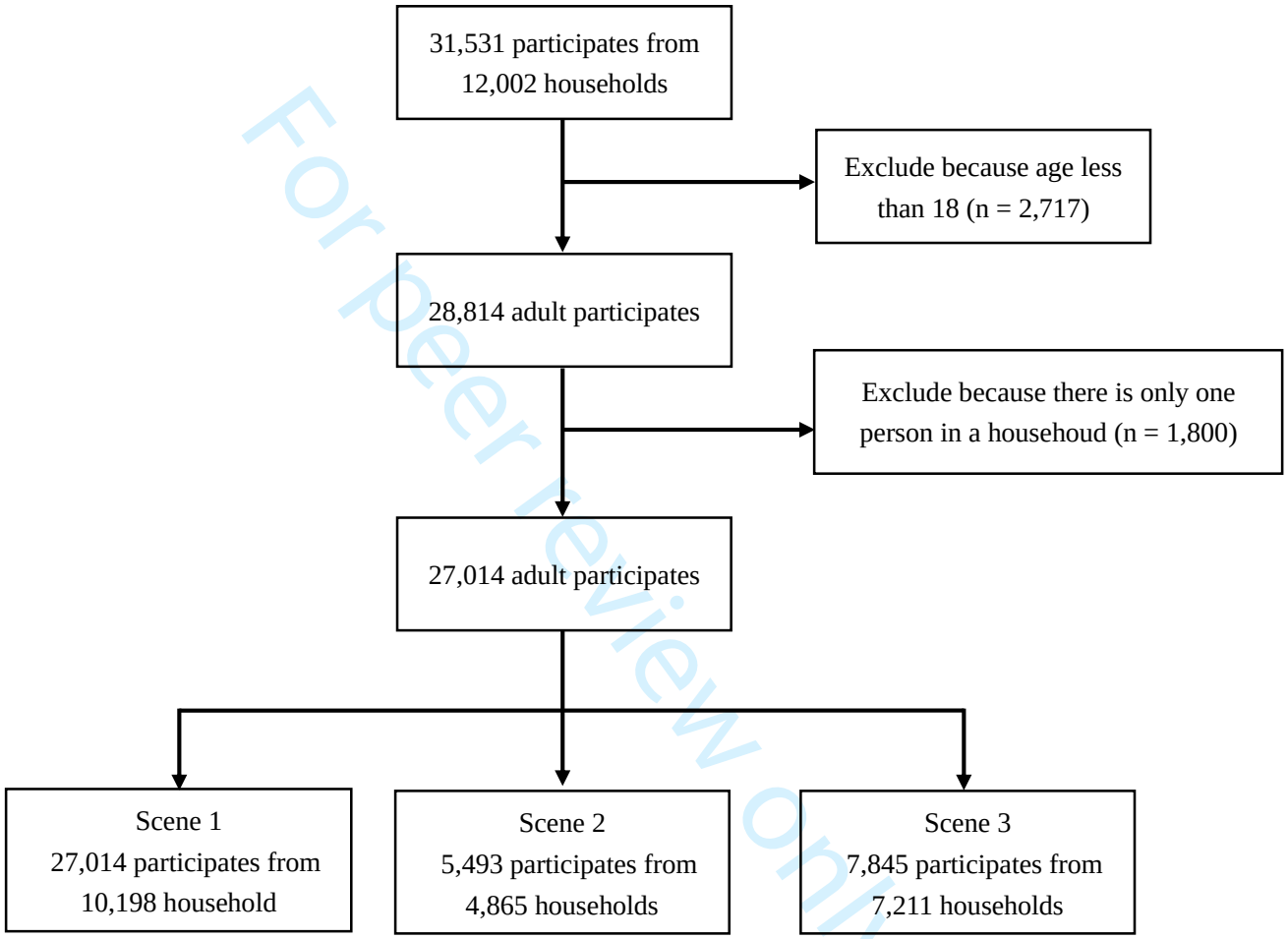
The chronic conditions on the top of table represented the status of children. The chronic conditions on the left of the table represented the status of their parents. The analyses of IHD and CVD were not conducted because of low prevalence rate in this subset. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, marriage status, drinking and smoking.

Table 4 The adjusted associations of chronic conditions between wife and their own husband - Scene 3 (N = 7,844 spouses)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	1.58 (1.41-1.77)	<.0001	1.55 (1.38-1.74)	<.0001	1.48 (1.22-1.80)	<.0001	1.64 (1.09-2.46)	0.0166	0.84 (0.56-1.26)	0.3992	1.35 (0.96-1.90)	0.0892
Hypertension	1.59 (1.42-1.79)	<.0001	1.63 (1.45-1.84)	<.0001	1.46 (1.20-1.77)	0.0001	1.60 (1.08-2.37)	0.0182	0.76 (0.51-1.14)	0.1783	1.11 (0.79-1.56)	0.5353
Diabetes	1.35 (1.13-1.63)	0.0011	1.29 (1.07-1.55)	0.0069	1.57 (1.21-2.03)	0.0007	1.48 (0.90-2.44)	0.1197	0.57 (0.27-1.21)	0.1427	1.02 (0.59-1.77)	0.9357
IHD	1.06 (0.72-1.55)	0.7695	0.96 (0.65-1.42)	0.8379	1.22 (0.71-2.09)	0.4762	6.58 (3.78-11.43)	<.0001	1.68 (0.76-3.69)	0.1994	1.17 (0.42-3.25)	0.7684
CVD	1.10 (0.72-1.67)	0.6596	0.80 (0.52-1.23)	0.3101	0.99 (0.54-1.82)	0.9847	1.36 (0.53-3.48)	0.5263	3.62 (1.86-7.07)	0.0002	1.28 (0.46-3.54)	0.6403
Obesity	1.29 (0.90-1.85)	0.1670	0.87 (0.59-1.29)	0.4888	1.69 (0.99-2.88)	0.0553	1.03 (0.27-3.96)	0.9700	0.58 (0.08-4.31)	0.5953	5.10 (2.93-8.88)	<.0001

Note:

The chronic conditions on the top of table represented the status of wives. The chronic conditions on the left of the table represented the status of their husband. The generalized estimating equations (GEE) model was adjusted for age, health insurance status, education status, drinking and smoking.



Notes: There were 4 participates missing in education status or marriage status in scene 1. There were 4 participates missing in education status or marriage status in scene 2. There was 1 participate missing in education status or marriage status in scene 3.

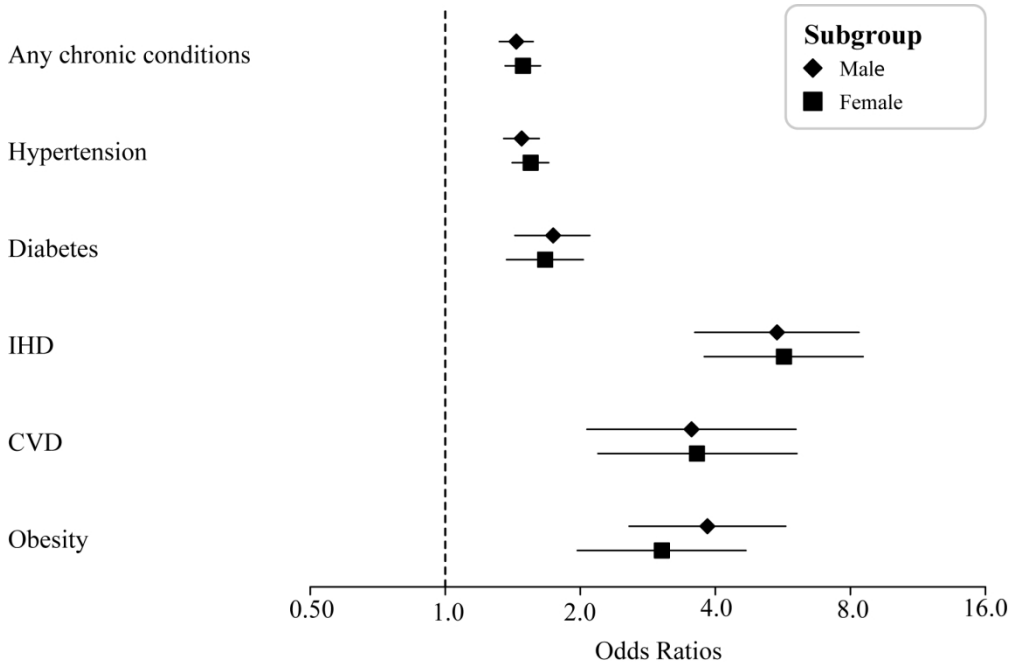


Figure 2 The forest plot of five chronic conditions subgroup analysis categorized by gender. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

163x108mm (300 x 300 DPI)

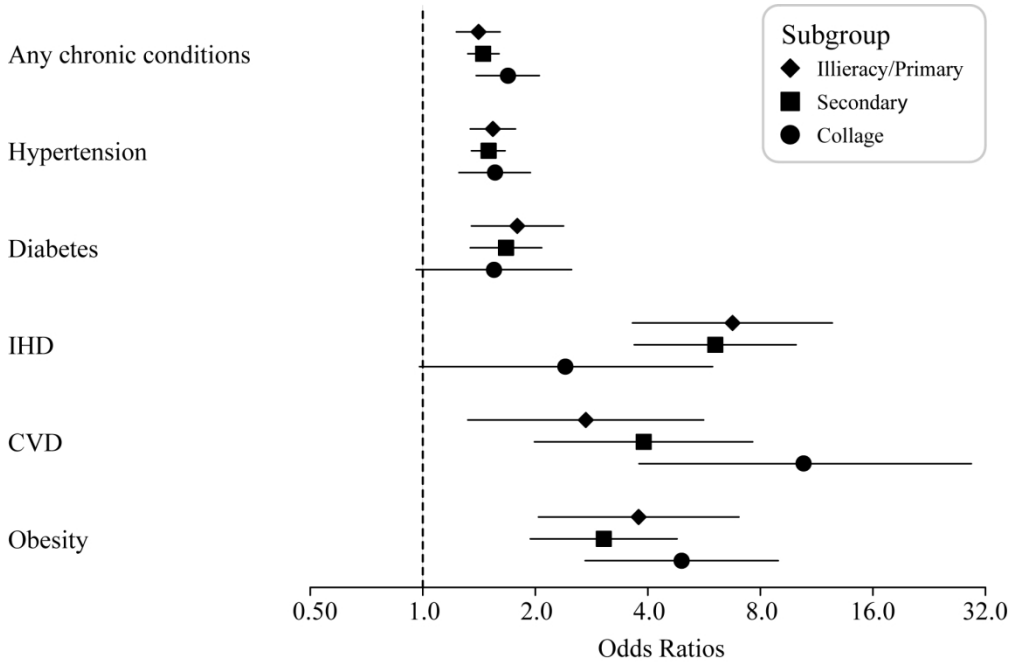


Figure 3 The forest plot of five chronic conditions subgroup analysis categorized by education status. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

163x108mm (300 x 300 DPI)

Table S1 The crude associations between one's chronic conditions and the disease status of their own household members - Scene 1 (N = 27,010)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	1.60 (1.49-1.73)	<.0001	1.63 (1.51-1.76)	<.0001	1.49 (1.35-1.66)	<.0001	1.60 (1.31-1.96)	<.0001	1.35 (1.09-1.67)	0.0059	1.30 (1.09-1.54)	0.0029
Hypertension	1.57 (1.47-1.69)	<.0001	1.65 (1.52-1.78)	<.0001	1.40 (1.27-1.55)	<.0001	1.51 (1.24-1.83)	<.0001	1.14 (0.92-1.41)	0.2177	1.10 (0.93-1.29)	0.2617
Diabetes	1.36 (1.24-1.48)	<.0001	1.30 (1.20-1.42)	<.0001	1.73 (1.45-2.08)	<.0001	1.23 (0.93-1.63)	0.1493	1.29 (0.96-1.74)	0.0910	1.44 (1.15-1.80)	0.0015
IHD	1.40 (1.19-1.65)	<.0001	1.40 (1.19-1.65)	<.0001	1.26 (0.96-1.67)	0.0978	7.35 (5.04-10.72)	<.0001	2.06 (1.30-3.25)	0.0019	0.89 (0.54-1.47)	0.6472
CVD	1.20 (1.01-1.43)	0.0422	1.08 (0.89-1.29)	0.4362	1.25 (0.95-1.66)	0.1133	1.98 (1.26-3.13)	0.0032	4.45 (2.66-7.44)	<.0001	0.61 (0.31-1.18)	0.1400
Obesity	1.22 (1.06-1.41)	0.0071	1.05 (0.91-1.21)	0.4786	1.32 (1.07-1.64)	0.0104	0.82 (0.50-1.36)	0.4434	0.58 (0.30-1.12)	0.1056	3.43 (2.36-4.98)	<.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members.

Table S2 The adjusted associations of subgroup analyses in all adult household members

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Male												
Any chronic conditions	1.44 (1.32-1.57)	<.0001	1.44 (1.31-1.57)	<.0001	1.22 (1.07-1.41)	0.0044	1.14 (0.85-1.53)	0.3852	1.14 (0.84-1.56)	0.4038	1.20 (0.95-1.51)	0.1172
Hypertension	1.43 (1.31-1.56)	<.0001	1.48 (1.35-1.62)	<.0001	1.21 (1.05-1.39)	0.0070	1.04 (0.78-1.38)	0.8069	0.88 (0.64-1.19)	0.4061	1.03 (0.81-1.30)	0.8218
Diabetes	1.47 (1.28-1.67)	<.0001	1.31 (1.15-1.50)	<.0001	1.74 (1.43-2.10)	<.0001	1.18 (0.78-1.77)	0.4359	1.33 (0.88-2.03)	0.1776	1.55 (1.13-2.12)	0.0070
IHD	1.12 (0.87-1.43)	0.3866	1.14 (0.88-1.47)	0.3252	0.93 (0.63-1.39)	0.7375	5.49 (3.60-8.36)	<.0001	1.45 (0.74-2.86)	0.2764	0.70 (0.32-1.55)	0.3791
CVD	0.93 (0.70-1.24)	0.6254	0.80 (0.59-1.08)	0.1487	0.94 (0.61-1.46)	0.7936	1.64 (0.84-3.22)	0.1484	3.54 (2.07-6.05)	<.0001	0.68 (0.28-1.67)	0.4042
Obesity	1.65 (1.33-2.04)	<.0001	1.31 (1.06-1.61)	0.0115	1.27 (0.93-1.74)	0.1271	1.04 (0.52-2.07)	0.9131	0.87 (0.40-1.93)	0.7368	3.84 (2.57-5.74)	<.0001
Female												
Any chronic conditions	1.49 (1.36-1.63)	<.0001	1.49 (1.36-1.63)	<.0001	1.39 (1.21-1.60)	<.0001	1.31 (1.01-1.71)	0.0453	0.91 (0.68-1.22)	0.5335	1.39 (1.10-1.75)	0.0056
Hypertension	1.49 (1.36-1.62)	<.0001	1.55 (1.41-1.70)	<.0001	1.26 (1.10-1.45)	0.0011	1.32 (1.02-1.71)	0.0365	0.86 (0.64-1.15)	0.3052	1.15 (0.92-1.45)	0.2201

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Diabetes	1.31 (1.15-1.49)	<.0001	1.28 (1.12-1.46)	0.0003	1.67 (1.37-2.03)	<.0001	0.95 (0.65-1.40)	0.8038	0.95 (0.60-1.49)	0.8158	1.32 (0.96-1.81)	0.0902
IHD	1.06 (0.82-1.36)	0.6716	1.01 (0.78-1.31)	0.9455	1.09 (0.75-1.59)	0.6389	5.69 (3.78-8.54)	<.0001	1.47 (0.75-2.87)	0.2645	1.03 (0.52-2.01)	0.9400
CVD	0.97 (0.74-1.26)	0.8189	0.83 (0.63-1.09)	0.1782	1.16 (0.77-1.75)	0.4648	1.43 (0.72-2.82)	0.3023	3.64 (2.19-6.08)	<.0001	0.52 (0.19-1.39)	0.1907
Obesity	1.19 (0.94-1.49)	0.1443	1.00 (0.79-1.27)	0.9974	1.52 (1.11-2.09)	0.0100	0.65 (0.28-1.50)	0.3101	0.27 (0.06-1.11)	0.0699	3.04 (1.97-4.68)	<.0001
Illieracy/Primary												
Any chronic conditions	1.41 (1.23-1.61)	<.0001	1.50 (1.31-1.71)	<.0001	1.16 (0.97-1.38)	0.1064	0.95 (0.68-1.34)	0.7815	1.00 (0.74-1.35)	0.9919	1.28 (0.92-1.80)	0.1470
Hypertension	1.44 (1.26-1.64)	<.0001	1.54 (1.34-1.77)	<.0001	1.12 (0.94-1.33)	0.2053	0.97 (0.70-1.35)	0.8688	0.99 (0.74-1.34)	0.9727	1.00 (0.72-1.38)	0.9855
Diabetes	1.20 (1.00-1.43)	0.0445	1.22 (1.03-1.44)	0.0229	1.79 (1.35-2.38)	<.0001	0.70 (0.40-1.24)	0.2242	0.77 (0.48-1.26)	0.3011	1.24 (0.77-2.00)	0.3733
IHD	1.05 (0.74-1.48)	0.7975	0.97 (0.70-1.36)	0.8720	0.86 (0.48-1.54)	0.6177	6.74 (3.64-12.46)	<.0001	2.03 (1.05-3.92)	0.0360	1.26 (0.48-3.36)	0.6389
CVD	0.94 (0.68-1.29)	0.6994	0.85 (0.62-1.17)	0.3135	0.83 (0.50-1.39)	0.4814	1.86 (0.91-3.80)	0.0883	2.73 (1.32-5.64)	0.0066	1.17 (0.49-2.81)	0.7180

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Obesity	1.31 (0.99-1.73)	0.0581	1.07 (0.81-1.40)	0.6397	1.46 (1.01-2.13)	0.0450	1.02 (0.45-2.32)	0.9649	0.62 (0.25-1.54)	0.3065	3.78 (2.04-7.01)	<.0001
Seconary												
Any chronic conditions	1.45 (1.32-1.60)	<.0001	1.43 (1.29-1.58)	<.0001	1.42 (1.23-1.62)	<.0001	1.46 (1.10-1.95)	0.0096	0.97 (0.69-1.37)	0.8698	1.13 (0.91-1.41)	0.2763
Hypertension	1.46 (1.33-1.61)	<.0001	1.50 (1.35-1.66)	<.0001	1.32 (1.16-1.51)	<.0001	1.42 (1.07-1.88)	0.0138	0.76 (0.53-1.08)	0.1227	1.00 (0.80-1.25)	0.9899
Diabetes	1.42 (1.25-1.62)	<.0001	1.29 (1.13-1.46)	0.0001	1.67 (1.34-2.08)	<.0001	1.28 (0.87-1.90)	0.2140	1.61 (1.02-2.53)	0.0395	1.46 (1.08-1.97)	0.0139
IHD	1.05 (0.82-1.33)	0.7096	1.11 (0.86-1.42)	0.4324	0.95 (0.65-1.39)	0.7949	6.06 (3.68-9.97)	<.0001	0.83 (0.33-2.06)	0.6857	0.51 (0.21-1.20)	0.1231
CVD	0.93 (0.70-1.22)	0.5950	0.83 (0.62-1.12)	0.2354	1.33 (0.90-1.96)	0.1528	0.81 (0.32-2.04)	0.6586	3.90 (1.99-7.63)	<.0001	0.24 (0.06-0.98)	0.0467
Obesity	1.32 (1.06-1.64)	0.0132	1.14 (0.92-1.41)	0.2223	1.30 (0.97-1.74)	0.0767	0.73 (0.34-1.57)	0.4245	0.67 (0.24-1.86)	0.4398	3.05 (1.94-4.79)	<.0001
Collage												
Any chronic conditions	1.69 (1.39-2.05)	<.0001	1.55 (1.25-1.91)	<.0001	1.22 (0.88-1.68)	0.2355	1.05 (0.63-1.75)	0.8497	1.12 (0.56-2.23)	0.7439	1.99 (1.36-2.89)	0.0003
Hypertension	1.53	<.0001	1.56	<.0001	1.17	0.3432	0.93	0.7628	0.67	0.2673	1.62	0.0103

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
	(1.26-1.84)		(1.25-1.94)		(0.85-1.61)		(0.56-1.53)		(0.33-1.36)		(1.12-2.33)	
Diabetes	1.70 (1.33-2.16)	<.0001	1.60 (1.22-2.09)	0.0007	1.55 (0.96-2.50)	0.0742	1.23 (0.63-2.41)	0.5452	1.22 (0.51-2.93)	0.6546	1.69 (1.08-2.65)	0.0220
IHD	1.21 (0.80-1.84)	0.3577	1.02 (0.64-1.63)	0.9371	1.28 (0.69-2.39)	0.4309	2.41 (0.98-5.96)	0.0557	1.68 (0.58-4.87)	0.3376	1.58 (0.67-3.70)	0.2928
CVD	1.20 (0.69-2.09)	0.5079	0.72 (0.37-1.39)	0.3256	0.57 (0.20-1.62)	0.2923	2.32 (0.85-6.28)	0.0988	10.43 (3.71-29.34)	<.0001	0.88 (0.21-3.64)	0.8569
Obesity	2.34 (1.52-3.60)	0.0001	1.51 (0.94-2.42)	0.0848	1.70 (0.78-3.71)	0.1829	0.83 (0.18-3.93)	0.8179	-	-	4.93 (2.72-8.93)	<.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, marriage status, drinking and smoking. The adjusted GEE model was not fit for estimate the association between CVD and obesity in the "Collage" subgroup.

Table S3 The crude associations of chronic conditions between children and their own parents - Scene 2 (N = 5,489 dyads)

Exposure:	Any chronic conditions		Hypertension		Diabetes		Obesity	
chronic condition status of parents	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	6.00(4.96-7.25)	<.0001	6.60(5.25-8.28)	<.0001	6.36(3.98-10.18)	<.0001	2.91(2.01-4.20)	<.0001
Hypertension	4.72(3.95-5.64)	<.0001	7.14(5.73-8.90)	<.0001	3.32(2.24-4.90)	<.0001	1.61(1.13-2.29)	0.0085
Diabetes	2.26(1.78-2.87)	<.0001	1.78(1.33-2.38)	<.0001	11.28(7.65-16.62)	<.0001	1.57(0.93-2.67)	0.0941
Obesity	3.09(2.07-4.60)	<.0001	0.75(0.38-1.48)	0.4126	1.98(0.79-4.94)	0.1449	14.88(9.35-23.68)	<.0001

Note:

The chronic conditions on the top of table represented the status of children. The chronic conditions on the left of the table represented the status of their parents. The analyses of IHD and CVD were not conducted because of low prevalence rate in this subset.

Table S4 The crude associations of chronic conditions between wife and their own husband - Scene 3 (N = 7,844 spouses)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	2.88 (2.61-3.18)	<.0001	2.80 (2.53-3.10)	<.0001	2.35 (1.96-2.82)	<.0001	3.41 (2.32-5.02)	<.0001	1.82 (1.24-2.67)	0.0022	1.65 (1.20-2.26)	0.0020
Hypertension	2.92 (2.64-3.23)	<.0001	2.94 (2.65-3.26)	<.0001	2.31 (1.93-2.78)	<.0001	3.30 (2.27-4.80)	<.0001	1.62 (1.10-2.38)	0.0147	1.39 (1.01-1.93)	0.0453
Diabetes	2.09 (1.78-2.46)	<.0001	1.97 (1.67-2.33)	<.0001	2.12 (1.64-2.75)	<.0001	2.51 (1.55-4.05)	0.0002	0.92 (0.44-1.89)	0.8143	1.20 (0.70-2.06)	0.5082
IHD	2.84 (2.01-4.01)	<.0001	2.54 (1.80-3.59)	<.0001	2.38 (1.44-3.95)	0.0008	18.21 (11.18-29.63)	<.0001	5.01 (2.39-10.53)	<.0001	1.55 (0.57-4.26)	0.3911
CVD	2.91 (2.01-4.19)	<.0001	2.18 (1.51-3.15)	<.0001	2.02 (1.15-3.55)	0.0150	3.68 (1.58-8.53)	0.0025	10.16 (5.51-18.73)	<.0001	1.75 (0.64-4.80)	0.2782
Obesity	1.02 (0.74-1.39)	0.9177	0.73 (0.51-1.04)	0.0822	1.42 (0.84-2.38)	0.1863	0.72 (0.18-2.94)	0.6484	0.39 (0.05-2.83)	0.3542	4.73 (2.72-8.23)	<.0001

Note:

The chronic conditions on the top of table represented the status of wives. The chronic conditions on the left of the table represented the status of their husband.

Statistical Analysis Plan

Study design

From 1993 to 2013, the NHSS has been conducted for five times (every five years) which is a cross-sectional survey. The latest one was conducted in 2013, which was the fifth one. The 5th Health Service Survey of Shanghai was the extension of 5th NHSS. This survey was organized and conducted by the Shanghai Municipal Commission Health and Family Planning. The sampling method and quality assurance measures used in Shanghai survey were consistent with the national sampling approach and principle. The fifth Health Service Survey of Shanghai cover all of the 17 districts in Shanghai, and a three-stage, stratified, random sampling method was adopted. First stage, 100 towns/townships were selected randomly from all these 17 districts. Second stage, one thousand villages/communities were sampled randomly from these selected towns/townships. Third stage, about 12,000 households were identified randomly.

A face-to-face interview approach using structured household questionnaire, which was developed by the National Commission Health and Family Planning of China, was conducted for each household. The questionnaire contained the general information of household, the demographic characteristics of residents, the relationship of household members, self-reported illness and injury, outpatient and inpatient information.

To ensure the quality of this survey, some quality assurance measures were applied during the process of data collection. Logic errors would be checked among the data by survey constitutors. If there were logic errors, the investigators would contact the household members and verify the relevant information. The accuracy of data information were assessed by revisit-approach. The investigators revisited 5% of the sampled households and collected ten key questions to check the consistency of the information recorded. The consistency rates between these two visits was near to 99 %.

Data management

Those who meet the following conditions will be excluded.

1. less than 18 years old
2. only one person in a household

Because the NHSS of Shanghai conducted well, there was little data missing in the data set. If one participate missed some important variables, he/she will be excluded from analyses.

For scene 1 (all household members), if any member in same household has a chronic condition this participate will be defined as an exposed one. For scene 2, if any child's parent has a chronic condition, then this child will be defined as an exposed one. For scene 3, if husband has a chronic condition, then his wife will be defined as an exposed one.

The generalized estimating equations (GEE) model with logit link will be used to estimate the odds ratio and 95% confidence interval of the chronic condition exposure.

Statistical analysis

To adjust some socio-demographic characteristics, we will include following variables in GEE model to control the possible confoundings. The covariates are age (continuously specified in years), education status (illiteracy/primary, secondary or college), health insurance status (yes or no), smoking (yes or no), drinking (yes or no).

Except the analyses of spouse subset, gender (male or female) and marriage status (married, unmarried, divorced or widowed). For scene 3, there were only married women included in the analyses, so gender and marriage status will not be included in the GEE model.

Subgroup analysis

We are planed to performed two subgroup analysis. One is by gender (male or female) and the other is by education status (illiteracy/primary, secondary or collage). Illiteracy/primary means the education years were from 0 to 5 years, secondary means the education years were from 6 to 12 years, and collage means the education years of residents were higher than 12 years including undergraduate and graduate degrees. The reason why we perfrom this two subgroup analysis is this two factors may have a significant incluence on living habits which is the cause of chronic conditions.

Sensitivity analysis

We will also estimate the unadjusted odds ratio and 95% confidence interval as sensitivity analysis.

Supplementary S1 The STROBE checklist

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Check
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes. We had indicated that this study is a cross-sectional study.
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes. These information was listed in "Abstract".
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes. The research about the concordance of chronic conditions among the household members could cause people and health management department to pay attention to the effect of co-residence factor in the prevalence of some chronic diseases.
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes. We did effort to test and explore the hypothesis that whether one's chronic conditions are related to the others with chronic conditions living in the same household.
Methods			
Study design	4	Present key elements of study design early in the paper	Yes. The data for this study was from the fifth Health Service Survey of Shanghai in 2013 (the extension of China's National Health Service Survey-NHSS), and this is a cross-sectional survey study.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes. This health survey was conducted in Shanghai, China, in 2013. Details could be found in "Data source" section.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Yes. In our study, we included the households with at least two adults who aged 18 or older.
Variables	7	Clearly define all outcomes, exposures, predictors,	Yes. We chose five chronic

		potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	conditions with high prevalence: hypertension, diabetes, Ischemic heart disease (IHD), cerebrovascular disease (CVD), obesity. Details could be found in "Five chronic conditions" section.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes. These five chronic conditions were from the self-reported records in the questionnaires, and we chose these diseases according to the disease coding list of the NHSS.
Bias	9	Describe any efforts to address potential sources of bias	Yes. Some socio-demographic characteristics would be included in our analyses as covariates: Age, gender, education status, marriage status, health insurance status, smoking, drinking.
Study size	10	Explain how the study size was arrived at	Yes. A total of 10,198 households (27,014 participants) with at least two adults who aged 18 or older were included in our study, and details could be found in figure 1.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes. Then the generalized estimating equations (GEE) model with logit link would be used to find out the relationship between one's chronic conditions and the others with chronic conditions living in the same household. And we would estimate these associations in three different household scenes: all household members, dyads of parents and children, and spouses.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes. Then the generalized estimating equations (GEE)

			model with logit link would be used in our study with adjusting for age, gender, health insurance status, education status, marriage status, drinking and smoking.
		(*b*) Describe any methods used to examine subgroups and interactions	Yes. The subgroup analyses would be conducted in all household members scene according to two pre-defined stratification factors: sex (male or female), education (illiteracy/primary, secondary, and college).
		(*c*) Explain how missing data were addressed	Yes. We did not conducted any statistical model to deal with the missing data because of low missing data rate. The observation with missing data would be excluded from the final analyses.
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Yes. The GEE model would be applicable to household data.
		(*e*) Describe any sensitivity analyses	Yes. We also conducted crude GEE models to find out the relationship.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes. The details could be found in the first paragraph of "Results" and figure 1.
		(b) Give reasons for non-participation at each stage	Yes. The details could be found in the first paragraph of "Results" and figure 1.
		(c) Consider use of a flow diagram	Yes. The figure 1 is a flow diagram.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes. The details could be found in the first paragraph of "Results" and table 1.
		(b) Indicate number of participants with missing data for each variable of interest	Yes. The details could be found in the first paragraph of "Results" and figure 1.
Outcome data	15*	Report numbers of outcome events or summary measures	Yes. The details could be found in table 1.

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Yes. The final conclusion was based on the results of the adjusted models. The results of adjusted model were listed in table 2-4, and those of crude model were available in the supplemental tables.
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes. The results of subgroup analyses were shown in figure 2 and supplemental table S2.
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes. We found that the participants who live with the household members with chronic conditions were associated with 46% higher OR of having one or more chronic condition. For these five chronic conditions, the above relationship was observed in each same chronic condition.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes. We discussed four points of limitation in the "Discussion" section.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes. The evidence about the effect of co-residence factor in some chronic conditions would suggest that people should pay more attention to their health status, especially those whose household members have chronic conditions. And the mechanisms about these associations should be investigated by further research.
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes. The relationships of chronic conditions among the household members were consistent in three

			different scenes and subgroups.
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	This study was conducted under a grant from the Fourth Round of Shanghai Three-year Action Plan on Public Health Discipline and Talent Program: Evidence-based Public Health and Health Economics(No. 15GWZK0901).

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The concordance of chronic conditions among the household members in Shanghai: a cross-sectional study

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The concordance of chronic conditions among the household members in Shanghai: a cross-sectional study

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Abstract

Objectives: Members living in the same household tend to share some similar behaviors and environment. We want to quantitatively assess the associations of chronic conditions to investigate the concordance of disease status among the household members.

Setting: Shanghai, China.

Participants: Our data was from the fifth Health Service Survey in Shanghai in 2013. 12,002 households with 31,531 residents were selected in this survey by using a three-stage, stratified, random sampling method.

Outcome measures: Five highly prevalent chronic conditions, namely hypertension, diabetes, ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity were chosen. The generalized estimating equations (GEE) model was used to estimate the associations adjusted for age, gender, education status, health insurance status, smoking, and drinking. Using a subsample of adult children with parents' chronic conditions as the key risk factor and a subsample of wives with the chronic conditions of the husband as key risk factor, we reran our GEE models to explore chronic condition concordance within these relationships.

Results: A total of 10,198 households with 27,010 adult participants were included. For all household members, we found positive statistically significant associations between one's chronic conditions and the same disease status of their household members (hypertension [odds ratio (OR) = 3.26, 95% confidence interval (CI): 3.02-3.52]; diabetes [OR = 1.68, 95% CI: 1.40-2.01]; IHD [OR = 5.31, 95% CI: 3.56-7.92]; CVD [OR = 3.40, 95% CI: 1.99-5.80]; and obesity [OR = 3.41, 95% CI: 2.34-4.96]). The results of analyzing ad-child subsample and spouse subsample also showed similar associations. Moreover, the potential concordance of different chronic conditions was found between hypertension and diabetes.

Conclusions: We found chronic condition concordance within households. This study provides evidence that the chronic conditions of other members of a household may be a significant risk factor for a household member's own health.

Strength & Limitations:

- This is the first study in China to estimate the risk to a household member's own health, which associate with the chronic conditions of other household members. We perform multivariate logistic models to estimate the association between an adult's own chronic condition status and the chronic condition status of other household members. These models are run on several samples including all adult household members, children with parents' chronic conditions as key risk factor, and wives with husband's chronic conditions as key risk factor. The definition and diagnosis of chronic condition for each participant was based on his or her self-reported records.
- This study was conducted in Shanghai and the results might not be generalized to other regions of China.
- Based as it is on cross-sectional data, this study does not estimate the risk of a new chronic condition in a household member, nor does it provide evidence of a causal relationship.

Key words: chronic conditions; household; concordance

Background

During the past three decades, China had experienced rapid social, economic and health services development[1 2]. Life expectancy has increased, lifestyles have changed, health care has become more accessible, and health insurance coverage has increased. Aligned with these remarkable improvements, healthcare concerns in the country have expanded from a narrow focus on infectious diseases to encompass treatment for non-communicable chronic conditions as well [2-4]. Research has shown the prevalence of hypertension increased from 5.11% in 1959 to 17.65% in 2002, and the prevalence of type 2 diabetes mellitus increased from 1% in 1980 to 9.7% in 2008[5-7]. In measuring disability-adjusted life-years (DALYs), non-communicable chronic conditions have become main contributors to a country's burden of disease. As of 2015, high systolic blood pressure, high fasting plasma glucose, and high body mass index respectively ranked 1st, 2nd, and 4th as important risk factors related to DALY. In 1990, the respective ranks of these three diseases were only 3rd, 10th and 13th.[8] As a typical city in China, Shanghai represents the direction of economic and healthy development in China. Noteworthily, aging is a significant issue in Shanghai. Moreover, this would bring about the new healthcare challenges for Chinese society and government[9].

Improvement in health care and innovation of new effective medical treatments will definitely play an increasingly important role in dealing with chronic conditions. Additionally, detection of risk factors and identification of individuals at high-risk are the important first steps in the prevention and treatment of chronic conditions. To study the risk factors, various research has mainly focused on the personal lifestyles related to the risk of chronic conditions, for example smoking, drinking, exercise, and diet[10-13]. Some genetic mechanisms are also considered as the risk factors of chronic conditions[14 15]. The household environment, which integrate the lifestyles, genetic mechanisms and environmental factors, would be an important research direction in controlling the

prevalence of chronic conditions[16].

Based on the fifth Health Service Survey of Shanghai, which was the extension of China's National Health Service Survey (NHSS) in 2013, the prevalence rate was 27.24% for hypertension and 7.05% for diabetes among 29,269 people aged 15 or older[17]. Regarding hypertension, 6,096 out of 12,002 households (50.79%) had at least one member with hypertension, and 1,733 households (28.43%) of these 6,096 households had at least two members suffering from the disease. This result showed the possibility of household clustering in the prevalence of chronic conditions. We hypothesized that there were associations between chronic conditions in the participants and the same conditions in their household members, we conducted the research and analyses using data from the fifth Health Service Survey of Shanghai. In this study, we focused on five highly prevalent chronic conditions: hypertension, diabetes, Ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity. Risk factors based on chronic conditions in other family members were detected for subsamples consisting of all household members, adult children, and wives, respectively.

Methods

Data source

In this study, we used data from the fifth Health Service Survey of Shanghai in 2013. This survey was organized and conducted by the Shanghai Municipal Commission Health and Family Planning, and was the extension of NHSS. From 1993 to 2013, the NHSS has been conducted for five times (every five years), and is a cross-sectional survey study[18]. The sampling method and quality assurance measures used in Shanghai survey were consistent with the national sampling approach and principle[19]. The fifth Health Service Survey of Shanghai was conducted in all of the 17 districts in Shanghai. The survey adopted a three-stage, stratified, random sampling method. In the first stage,

100 towns/townships were randomly selected from all these 17 districts. In the second stage, one thousand villages/communities were randomly sampled from the selected towns/townships. In the third stage, about 12,000 households were randomly selected. We conducted a face-to-face interview with each household using a structured household questionnaire developed by the National Commission Health and Family Planning of China. The questionnaire contained the general information of the households, the demographic characteristics of household members, relationships among them, their self-reported illnesses and injuries, as well as their outpatient and inpatient information.

To ensure the quality of this survey, certain assurance measures were applied during the process of data collection. Survey constitutors checked potential logic errors of the collected data. In case of any logic errors, the investigators would contact the household members and verify the relevant information. The accuracy of data information was assessed using the revisit approach. More specifically, the investigators revisited 5% of the sampled households and collected ten key questions to check the consistency of the information recorded. The consistency rate between these two visits was nearly 99 %. Additionally, the Myer's Blended index was 7.39, indicating that there was non-existence of age preference in this survey[17 20]. Finally, this survey collected the information of 12,002 households with 31,531 participants. We included the households with at least two adults aged 18 years or older.

Five chronic conditions

In this survey, we chose five chronic conditions with high prevalence rates: hypertension, diabetes, IHD, CVD, and obesity. The definition of these chronic conditions were based on the corresponding questions in the questionnaire, the disease coding list of the NHSS, and Body mass index (BMI). If a participant chose "YES" or

a specific disease code, he or she was considered to have the corresponding chronic condition.

Hypertension: Hypertension was indicated based on the question "Have you ever been told by a doctor that you have hypertension?" in the questionnaire.

Diabetes: Diabetes was indicated based on the question "Have you ever been told by a doctor that you have diabetes?" in the questionnaire.

IHD: The disease codes for IHD included angina pectoris (061), myocardial infarction (062), and other ischemic heart disease (063).

CVD: The disease code for CVD included cerebrovascular disease (067).

Obesity: Obesity was indicated by the World Health Organization (WHO) International BMI categories (BMI $\geq$ 30 kg/m^2)[21].

Covariates

Socio-demographic characteristics added to our models as covariates include age (continuously specified in years), education status (illiteracy/primary, secondary or college), health insurance status (yes or no), marriage status (married, unmarried, divorced or widowed), smoking (yes or no), and drinking (yes or no). Except the analyses of spouse subsample, gender (male or female) was also included as a covariate.

Statistical analyses

This study had five primary outcomes, each of which represented the status of each of the five chronic conditions, namely hypertension, diabetes, IHD, CVD, and obesity, in the participants ("No" or "Yes"). If a participant had any of these five chronic conditions ("Yes"), his or her status of having "Any chronic condition" is considered as "Yes". To make a comprehensive assessment, we settled three subsamples: all adult household members (the total sample), adult children (adult children subsample), and

wives (spouse subsample). In addition, we identified chronic conditions in the other household members as the exposure (or risk factor) in three subsamples.

For the first subsample of all adult household members, we included all household members aged 18 years or older. If any other residents (excluding self) have the given chronic conditions, the exposure status of household situation for each participant is identified as "Yes". For the second subsample of adult children, only adult children would be included in analyses, and those participants were excluded if the disease information of parents were not available. The chronic conditions status of their parents were considered as exposure. For the third subsample of spouses, we included married women in the analyses. We defined the chronic conditions of wives as the outcomes and the chronic conditions of husbands as the exposure.

The generalized estimating equations (GEE) model with logit link would be used to explore the associations between chronic conditions of participants and the conditions of the others living in the same household. We considered a two-level hierarchical structure of the model (individuals within households). The model was based on individual's data without taking sampling weight into account due to the lack of relevant information. The odds ratio (OR) and 95% confidence interval (CI) were estimated by the GEE model to indicate the association between any chronic condition or each given chronic condition of an individual and the same condition of household member (e.g., the association between the hypertensive status of a participants and that same condition in his or her other household members). Besides, the association of different chronic conditions would also be assessed (e.g., the association between hypertension in a participant and diabetes in other household members).

Adjusted models and unadjusted models were both used to estimate the associations in three household subsamples. The adjusted models included age, gender, health insurance status, education status, drinking and smoking; however, gender was

excluded in the third subsample. The final conclusion was based on the results of the adjusted models. The results of unadjusted models would be obtained in supplementary information. We chose the exchangeable working correlation matrix for GEE models. The subgroup analyses were conducted for the first subsample according to two pre-defined stratification factors: sex (male or female), education (illiteracy/primary, secondary, and college). We did not conducted any statistical model to deal with the missing data because of low missing data rates. Any observation with missing data would be excluded from the final analyses. All data management and statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC). All reported p values were two-sided and p value < 0.05 was regarded as statistically significant. This study was reported based on the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines (supplementary S1), and all analyses were conducted according to the statistical analysis plan (supplementary S2).

Patient and public involvement

This is a cross-sectional study based on survey responses. It includes no further patient involvement.

Results

A total of 10,198 households (27,010 participants) with at least two adults who aged 18 years or older were included in our study from the database of the fifth Health Service Survey of Shanghai in 2013. For the second subsample, there were 5,489 available records of adult children, and 7,844 records of spouses had been analyzed in the third subsample. The detail information was shown in flowchart (Fig. 1). Table 1 has shown the details of socio-demographic characteristics. The mean age of all included

participants was 52.63 years, and 31.34% (n=8,467) had at least one chronic condition. However, the adult children participants in the second subsample were young (36.01 years), and the prevalence rates of chronic conditions were much low (11.89%).

All household members

In the first subsample, the results indicated that the chronic conditions of participants was associated with the same conditions of others living in the same household (the diagonal of Table 2): any chronic condition (OR =3.03, 95% CI: 2.81-3.28), hypertension (OR =3.26, 95% CI: 3.02-3.52), diabetes (OR = 1.68, 95% CI: 1.40-2.01), IHD (OR = 5.31, 95% CI: 3.56-7.92), CVD (OR = 3.40, 95% CI: 1.99-5.80), and obesity (OR = 3.41, 95% CI: 2.34-4.96). The results also revealed that there were significantly positive associations for some different chronic conditions (diabetes and hypertension, diabetes and obesity). The OR was 1.19 (95% CI: 1.08-1.32) for diabetes to hypertension and 1.23 (95% CI: 1.11-1.36) for hypertension to diabetes. The OR was 1.36 (95% CI:1.08-1.73) for diabetes to obesity and 1.36 (95% CI: 1.09-1.70) for obesity to diabetes. More details s were presented in Table 2, and the results of unadjusted GEE models were listed in the Table S1.

In subgroup analysis, we found the similar associations for the sex subgroups and education level subgroups (Fig. 2, Fig. 3 and Table S2). However, no significant association was not found in the analyses of diabetes and IHD in the college education subgroup.

Adult children subsample

We did not conduct the analyses of IHD and CVD in this household subsample because of low prevalence rates (0.2% for IHD, and 0.15% for CVD). Table 3 listed the results of adjusted GEE models for adult children. The positive associations between chronic conditions of adult children and the same conditions of their parents were observed: any chronic condition (OR = 5.13, 95% CI: 4.20-6.28), hypertension (OR = 6.29, 95%

CI: 4.92-8.05), diabetes (OR = 11.56, 95% CI: 7.88-16.98), and obesity (OR = 13.85, 95% CI: 8.54-22.46). For different chronic conditions, the children with diabetes and obesity were associated with parents with hypertension (OR was 2.40 for diabetes, and OR was 1.69 for obesity). And the results also indicated that hypertension status of children was associated with the diabetes status of their parents (OR = 1.61). The results of unadjusted GEE models for the second household scene were listed in the Table S3.

Spouses subsample

The results of the spouses subsample are shown in the Table 4. Similar to the other two subsamples above , positive statistically significant associations were also observed between chronic conditions in husbands and the same conditions in their spouses: any chronic condition (OR = 1.58, 95% CI: 1.41-1.77), hypertension (OR = 1.63, 95% CI: 1.45-1.84), diabetes (OR = 1.57, 95% CI: 1.21-2.03), IHD (OR = 6.58, 95% CI: 3.78-11.43), CVD (OR = 3.62, 95% CI: 1.86-7.07), and obesity (OR = 5.09, 95% CI: 2.92-8.86). The wives with diabetes and IHD were associated with the hypertension status of their husbands (OR was 1.46 for diabetes, and OR was 1.60 for IHD). And the association between the hypertension status of wives and the diabetes status of husbands was also indicated (OR = 1.29). The information of unadjusted GEE models could be available in Table S4.

Discussion

In China, Shanghai has the heaviest burden of noncommunicable diseases because of its largest population and ageing population[22]. We conducted in-depth analyses of the associations among five pre-selected chronic conditions status within the household members in Shanghai, China. Using the data of the fifth Health Service Survey, we found that the participants living with their household members with chronic conditions were associated with 46% higher OR of having one or more chronic conditions. For

each of five chronic conditions, the above associations were observed in each same chronic condition. We also found the similar associations in children subsample and spouses subsample. These results were consistent with some other research results[16 23-25]. Additionally, the results suggested potential associations between the different chronic conditions, for example hypertension and diabetes.

We chose five chronic conditions (hypertension, diabetes, IHD, CVD, and obesity) as the target diseases of our study because of the highest prevalence rates in this health service survey. Based on the current knowledge, the incidence of the chronic conditions is the result of the combination of multiple factors. The members of the same household would live in the same environment, and might have the similar behaviors. In addition, some of them would have genetic associations (e.g. parents and children, or brothers and sisters). Some research reported the association between the family health history and risk of disease[26-28]. Besides, if a member of the household was diagnosed with a certain type of chronic condition, the likelihood of the other family members having their diagnostic tests performed was higher. This phenomenon might cause reporting bias and lead to the association of chronic conditions among household members. Our study pointed out the positive associations between chronic conditions in adults and the same conditions in their household members. According to the results of all household members, we found that the ORs for IHD and CVD were high, and the 95% CI of the corresponding ORs was wide. An explanation might be that the prevalence rates of IHD and CVD were only 1.68% and 1.38%, respectively. Moreover, low prevalence rates might reduce the accuracy of the statistical model estimation. However, the results of both the adjusted GEE model and the unadjusted one showed the positive associations for these two chronic conditions.

In order to further explore the effect of a common living environment on the chronic conditions, we conducted analyses in two subsamples. In the adult children sample,

genetic factors had a significant impact on children's chronic conditions, besides certain environment and behavior factors. Meanwhile, the effect of genetic factors was excluded from the analyses of the spouses subsample. The positive associations, which were similar to the results of all household members, were found in these two subsamples. These findings were consistent with some previous studies[23-25 29 30]. The results of analyses in these two special subsamples showed the effects of genetic factors and those of a common living environment without genetic ties on the associations of interest. Moreover, the adjusted ORs in analyses about children subsample were much higher (e.g. OR = 6.12 for hypertension association). However, we could make a conclusion that the effect of genetic factors was much more important. This might be because certain chronic conditions are age-related diseases, and the prevalence rates of adult children in this health service survey were low. For example, the prevalence of hypertension among adult children was only 8.86% (the mean of age was 39.16 years old), and prevalence rate for those whose parents had no hypertension was much lower (only 3.34%, the mean of age was 34.36 years old). Based on this consideration, we included the age covariate into the adjusted model. Therefore, these results might reflect the associations between chronic conditions in children and those in their parents despite high ORs. In order to show the effects of covariates more clearly, we listed the results of full models for three subsamples in the Table S5. We found that the effects of most covariates were consistent across three subsamples.

In addition to explore the association of the same chronic condition between participants and their household members, the results of different chronic conditions indicated that there was positive association between hypertension and diabetes. This association was seen in all three subsamples. The mechanisms and pathways could not be concluded in our study, but certain previous studies might provide some hypotheses. The hypertension and diabetes are the syndromes of metabolic syndrome (MetS). Some

risk factors for MetS, such as lifestyle, diet, family disease history, environment, might be the co-factors for the prevalence of hypertension and diabetes[31-33]. However, the exact mechanisms should need further investigation.

Although we did not provide certain specific risk factors for the prevalence of chronic conditions, the quantitative assessment showed the concordance of chronic conditions within households. We suggested that individuals whose household members had certain chronic conditions should pay more attention to their health status. Health education about chronic diseases and breaking some potential unhealthy behaviors might help reduce the prevalence rates of chronic conditions among those individuals. Moreover, regular health examination (e.g. measurement of blood pressure and weight) would be helpful for residents to monitor their own health status. Shanghai is the biggest and most developed city in China, and lends the development trend. Some researchers indicated that Shanghai Chronic Disease Self-Management Program (CDSMP), the most widely accepted self-management patient education programmer worldwide, could improved participants' health behavior, self-efficacy, and health status[22]. Maybe this program could be modified and acceptable to the healthy residents whose household members have chronic conditions. Moreover, the chronic condition concordance within households should also be given special care in other regions of China, and the relevant solutions should be worked out advanced. These would be beneficial for controlling the prevalence rate of chronic conditions and reducing the disease burden for the country and among residents.

Our study had several potential limitations. First, the definition and diagnosis of chronic condition for each participant was based on his or her self-reported records. This might lead to the potential risk of underreporting and misreporting. However, this survey was part of the NHSS and every investigator had undergone rigorous and formal training. Previous research has shown the agreement between biomedical and self-reported

measurements of certain chronic conditions in a Chinese national community sample[34]. Therefore, the records of these five chronic conditions would be reliable. Second, this study was conducted in Shanghai and the results could not represent the situation in other regions of China. Nevertheless, it could draw the attention of the public and health management departments to this problem. Third, our study could neither estimate the risk of new chronic conditions among household members nor find out a certain significant risk factor. We only pointed out the phenomenon that there were associations for the prevalence of chronic conditions at the household level. The mechanism and specific causes of cohabitation effects on prevalence of chronic conditions could not be presented by our study. These results suggested that we'd better pay attention to the health status of the health residents in the households with members with chronic conditions. Fourth, this study is a cross-sectional survey study, and several potential bias, such as recall bias, confounding bias and reporting bias, might not be completely avoided. The exclusion of households with only one family member might also cause some selection bias. To deal with the confounding bias, we conducted the analyses using the adjusted GEE models with some socio-demographic covariates.

Conclusions

In conclusion, our study indicated that one's chronic condition status was associated with the status of their household members in the Shanghai, China. The results of adult children and spouses subsamples were consistent with those of all household members. Additionally, analyses about different chronic conditions suggested possible positive associations between hypertension and diabetes. The mechanisms about these associations should be investigated by further research. However, the evidence about the association of chronic conditions for the same household members suggests that

people should pay more attention to their health status, especially those whose household members have chronic conditions. That might reduce the prevalence and increase the early detection rate about some chronic conditions.

List of abbreviations

IHD = ischemic heart disease

CVD = cerebrovascular disease

GEE = generalized estimating equations

OR = odds ratio

CI = confidence interval

DALYs = disability-adjusted life-years

NHSS = National Health Service Survey

BMI = body mass index

WHO = World Health Organization

STROBE = Strengthening the Reporting of Observational studies in Epidemiology

MetS = metabolic syndrome

CDSMP = Chronic Disease Self-Management Program

Declarations

Ethics approval and consent to participate

This cross-sectional questionnaire survey was organized by the Shanghai Municipal Commission Health and Family Planning. As we knew, this survey didn't contain any treatment, blood drawing or others intervention which might influence the health of participators. Informed consent was obtained by surveyors prior to data collection and personal information was with strict conservation during our analysis process. Thus no ethical approval is required for our study.

Consent for publication

We give my consent for information about myself/my child or ward/my relative (circle as appropriate) to be published in *BMJ Open.*

Data sharing

No.

Data availability statement

Data are available upon reasonable request.

Competing of interest

The authors declare that they have no competing interests.

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Authors' contribution

Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Jia He designed this study. Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Cheng Wu analysized the data. Prof. Qian He and Dr. Xinji Zhang checked the statistical analysis. Dr. Yibin Guo and Dr. Yingyi Qin wrote the manuscript. Mrs. Yuanjun Tang, Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Jia He revised this manuscript.

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Figure legends

Figure 1 The flow chart of participates selection of the three subsamples analysis

Figure 2 The forest plot of five chronic conditions subgroup analysis categorized by gender. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

Figure 3 The forest plot of five chronic conditions subgroup analysis categorized by education status. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

Table 1 Socio-demographic characteristics of participants

Characteristic	All household members	Children[a]	Wives[b]
No. of households	10,198	4,865	7,211
No. of participates	27,014	5,493	7,845
Age, years, mean (SD)	52.63(17.06)	36.01(12.18)	54.01(13.85)
Male, n (%)	13,182(48.8)	3,273(59.58)	-
Education status, n (%)[c,e]			
Illieracy/Primary	5,801(21.47)	334(6.08)	2,191(27.93)
Secondary	14,484(53.62)	2,481(45.17)	4,551(58.01)
Collage	6,727(24.9)	2,678(48.75)	1,102(14.05)
Marriage status, n (%)[f]			
Unmarried	3,124(11.56)	2,286(41.62)	-
Married	22,116(81.87)	2,924(53.23)	-
Divorced or widowed	1,772(6.56)	283(5.15)	-
Insurance, n (%)	26,011(96.29)	5,247(95.52)	7,575(96.56)
Drinking, n (%)	5,157(19.09)	944(17.19)	222(2.83)
Smoking, n (%)	6,392(23.66)	1,460(26.58)	166(2.12)
Chronic conditions, n (%)			
Any chronic conditions[d]	8,467(31.34)	653(11.89)	2,414(30.77)
Hypertension	7,245(26.82)	480(8.74)	2,102(26.79)
Diabetes	1,875(6.94)	110(2)	498(6.35)
IHD	455(1.68)	11(0.2)	117(1.49)
CVD	372(1.38)	8(0.15)	106(1.35)
Obesity	631(2.34)	128(2.33)	156(1.99)

Notes:

a The characteristics of children in parents-children subsample.

b The characteristics of wives in spouses subsample.

c "Illieracy/Primary" in education status means the education years were from 0 to 5 years, "secondary" means the education years were from 6 to 12 years, and "collage" means the education years of residents were higher than 12 years including undergraduate and graduate degrees.

d The participants had at least one chronic condition.

IHD: Ischemic Heart Disease; CVD: Cerebrovascular Disease.

e There were 2 participates missing in education status in data set.

f There were 2 participates missing in marriage status in data set.

Table 2 The adjusted associations between one's chronic conditions and the disease status of their own household members - Scene 1 (N = 27,010)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	3.03 (2.81-3.28)	<0.0001	1.46 (1.34-1.58)	<0.0001	1.25 (1.12-1.39)	<0.0001	1.23 (1.00-1.51)	0.0467	0.96 (0.77-1.19)	0.6906	1.29 (1.09-1.53)	0.0034
Hypertension	1.26 (1.17-1.37)	<0.0001	3.26 (3.02-3.52)	<0.0001	1.23 (1.11-1.36)	<0.0001	1.15 (0.94-1.40)	0.1742	0.84 (0.68-1.04)	0.1177	1.02 (0.86-1.20)	0.8257
Diabetes	1.38 (1.25-1.52)	<0.0001	1.19 (1.08-1.32)	0.0005	1.68 (1.40-2.01)	<0.0001	1.06 (0.79-1.42)	0.6846	1.10 (0.80-1.50)	0.5632	1.36 (1.08-1.73)	0.0099
IHD	1.08 (0.90-1.30)	0.3911	1.07 (0.88-1.29)	0.5015	1.00 (0.75-1.33)	0.9949	5.31 (3.56-7.92)	<0.0001	1.46 (0.90-2.35)	0.1224	0.90 (0.54-1.50)	0.6846
CVD	0.95 (0.77-1.16)	0.5856	0.81 (0.66-1.00)	0.0526	1.03 (0.76-1.40)	0.8473	1.51 (0.93-2.43)	0.0951	3.40 (1.99-5.80)	<0.0001	0.60 (0.31-1.15)	0.1251
Obesity	1.40 (1.18-1.66)	0.0001	1.06 (0.90-1.25)	0.4697	1.36 (1.09-1.70)	0.0076	0.86 (0.51-1.45)	0.5663	0.58 (0.29-1.15)	0.1172	3.41 (2.34-4.96)	<0.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, drinking and smoking.

Table 3 The adjusted associations of chronic conditions between children and their own parents - Scene 2 (N = 5,489 dyads)

Exposure:	Any chronic conditions		Hypertension		Diabetes		Obesity	
chronic condition status of parents	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	5.13(4.20-6.28)	<.0001	5.58(4.34-7.17)	<.0001	4.66(2.90-7.48)	<.0001	3.02(2.07-4.42)	<.0001
Hypertension	3.93(3.25-4.75)	<.0001	6.29(4.92-8.05)	<.0001	2.40(1.61-3.57)	<.0001	1.69(1.17-2.44)	0.0056
Diabetes	2.16(1.66-2.81)	<.0001	1.61(1.16-2.25)	0.0047	11.56(7.88-16.98)	<.0001	1.51(0.88-2.57)	0.1346
Obesity	5.23(3.24-8.45)	<.0001	1.00(0.45-2.21)	0.9951	2.47(0.95-6.42)	0.0639	13.85(8.54-22.46)	<.0001

Note:

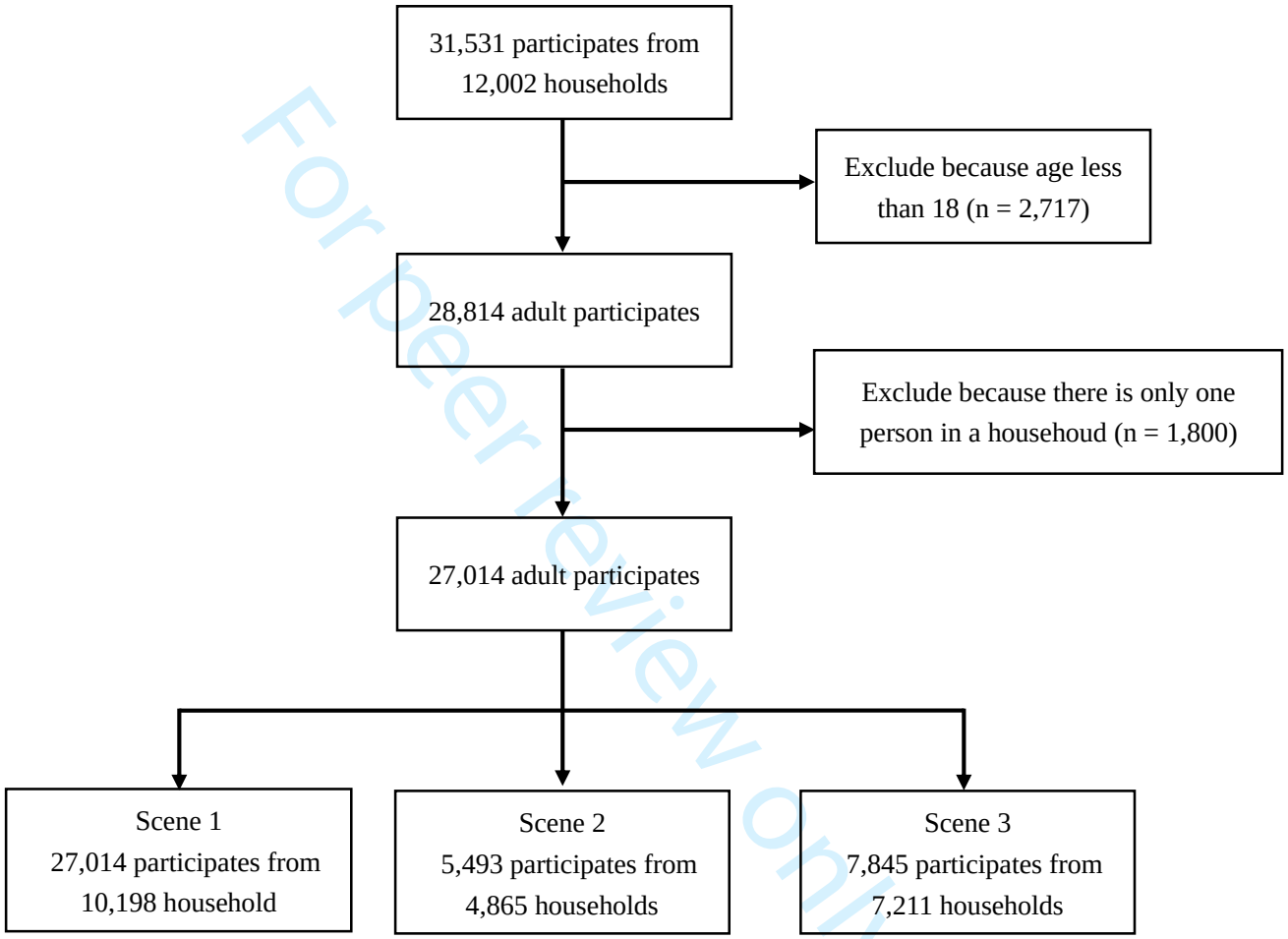
The chronic conditions on the top of table represented the status of children. The chronic conditions on the left of the table represented the status of their parents. The analyses of IHD and CVD were not conducted because of low prevalence rate in this subset. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, drinking and smoking.

Table 4 The adjusted associations of chronic conditions between wife and their own husband - Scene 3 (N = 7,844 spouses)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	1.58 (1.41-1.77)	<.0001	1.55 (1.38-1.74)	<.0001	1.48 (1.22-1.80)	<.0001	1.64 (1.09-2.46)	0.0166	0.84 (0.56-1.26)	0.3992	1.35 (0.96-1.90)	0.0892
Hypertension	1.59 (1.42-1.79)	<.0001	1.63 (1.45-1.84)	<.0001	1.46 (1.20-1.77)	0.0001	1.60 (1.08-2.37)	0.0182	0.76 (0.51-1.14)	0.1783	1.11 (0.79-1.56)	0.5353
Diabetes	1.35 (1.13-1.63)	0.0011	1.29 (1.07-1.55)	0.0069	1.57 (1.21-2.03)	0.0007	1.48 (0.90-2.44)	0.1197	0.57 (0.27-1.21)	0.1427	1.02 (0.59-1.77)	0.9357
IHD	1.05 (0.72-1.54)	0.7996	0.96 (0.65-1.42)	0.8379	1.22 (0.71-2.09)	0.4762	6.58 (3.78-11.43)	<.0001	1.68 (0.76-3.69)	0.1994	1.17 (0.42-3.25)	0.7684
CVD	1.10 (0.72-1.67)	0.6596	0.80 (0.52-1.23)	0.3101	0.99 (0.54-1.82)	0.9847	1.36 (0.53-3.48)	0.5263	3.62 (1.86-7.07)	0.0002	1.28 (0.46-3.54)	0.6403
Obesity	1.29 (0.90-1.85)	0.1670	0.87 (0.59-1.29)	0.4888	1.69 (0.99-2.88)	0.0553	1.03 (0.27-3.96)	0.9700	0.58 (0.08-4.31)	0.5953	5.09 (2.92-8.86)	<.0001

Note:

The chronic conditions on the top of table represented the status of wives. The chronic conditions on the left of the table represented the status of their husband. The generalized estimating equations (GEE) model was adjusted for age, health insurance status, education status, drinking and smoking.



Notes: There were 4 participates missing in education status or marriage status in scene 1. There were 4 participates missing in education status or marriage status in scene 2. There was 1 participate missing in education status or marriage status in scene 3.

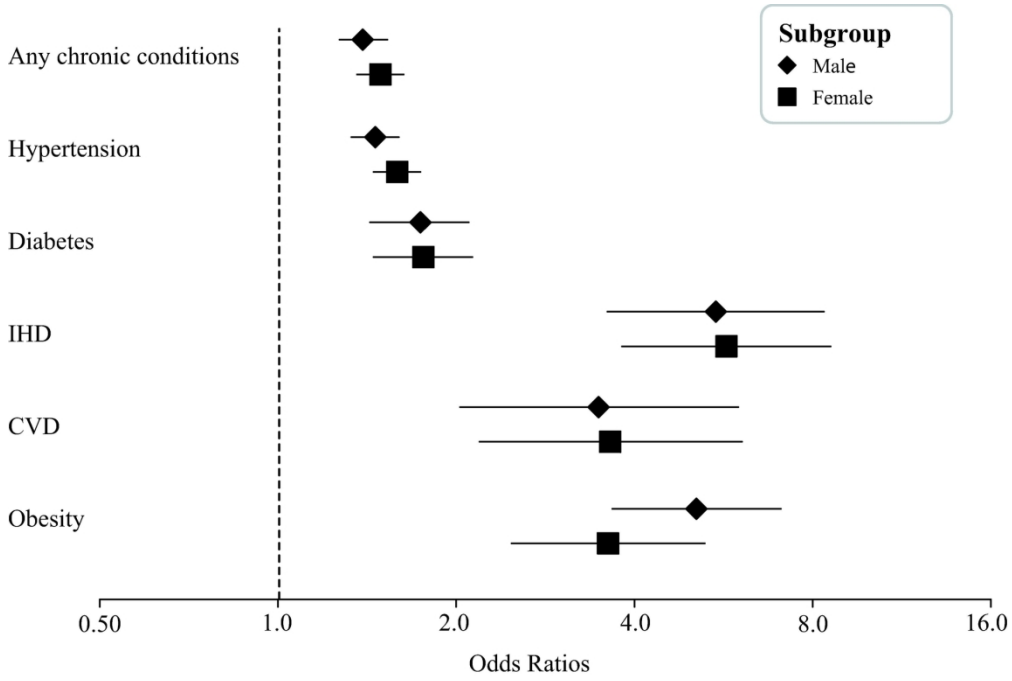


Figure 2 The forest plot of five chronic conditions subgroup analysis categorized by gender. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

171x115mm (300 x 300 DPI)

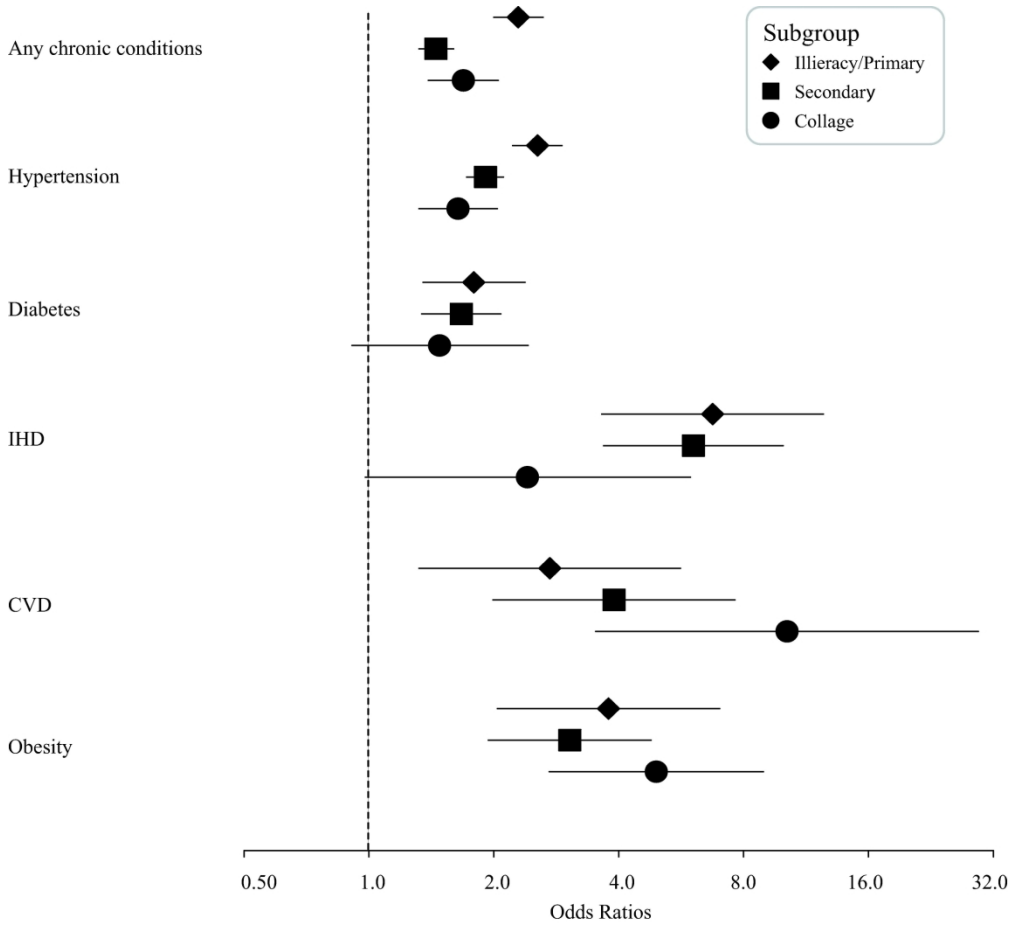


Figure 3 The forest plot of five chronic conditions subgroup analysis categorized by education status. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

204x187mm (300 x 300 DPI)

Table S1 The crude associations between one's chronic conditions and the disease status of their own household members - Scene 1 (N = 27,010)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	2.26 (2.26-3.81)	<.0001	2.89 (2.69-3.10)	<.0001	1.49 (1.35-1.66)	<.0001	1.34 (1.09-1.65)	0.0050	1.35 (1.09-1.67)	0.0059	1.30 (1.09-1.54)	0.0029
Hypertension	1.96 (1.07-3.57)	0.0282	1.65 (1.52-1.78)	<.0001	1.40 (1.27-1.55)	<.0001	1.51 (1.24-1.83)	<.0001	1.06 (1.32-0.86)	0.5683	1.02 (0.86-1.21)	0.8048
Diabetes	1.36 (1.24-1.48)	<.0001	1.14 (1.05-1.25)	0.0031	1.73 (1.45-2.08)	<.0001	1.23 (0.93-1.63)	0.1493	1.29 (0.96-1.74)	0.0910	1.44 (1.15-1.80)	0.0015
IHD	1.40 (1.19-1.65)	<.0001	1.40 (1.19-1.65)	<.0001	1.19 (0.88-1.59)	0.2568	7.35 (5.04-10.72)	<.0001	2.06 (1.30-3.25)	0.0019	0.89 (0.54-1.47)	0.6472
CVD	1.20 (1.01-1.43)	0.0422	1.08 (0.89-1.29)	0.4362	1.25 (0.95-1.66)	0.1133	1.98 (1.26-3.13)	0.0032	4.45 (2.66-7.44)	<.0001	0.61 (0.31-1.18)	0.1400
Obesity	1.22 (1.06-1.41)	0.0071	0.96 (0.83-1.11)	0.5997	1.32 (1.07-1.64)	0.0104	0.82 (0.50-1.36)	0.4434	0.58 (0.30-1.12)	0.1056	3.43 (2.36-4.98)	<.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members.

Table S2 The adjusted associations of subgroup analyses in all adult household members

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Male												
Any chronic conditions	1.39 (1.27-1.53)	<.0001	1.44 (1.31-1.57)	<.0001	1.22 (1.07-1.41)	0.0044	1.14 (0.85-1.53)	0.3852	1.14 (0.84-1.56)	0.4038	1.10 (0.87-1.39)	0.4386
Hypertension	1.38 (1.26-1.26)	<.0001	1.46 (1.33-1.60)	<.0001	1.21 (1.05-1.39)	0.0070	1.04 (0.78-1.38)	0.8069	0.88 (0.64-1.19)	0.4061	1.03 (0.81-1.30)	0.8218
Diabetes	1.47 (1.28-1.67)	<.0001	1.31 (1.15-1.50)	<.0001	1.74 (1.43-2.10)	<.0001	1.18 (0.78-1.77)	0.4359	1.33 (0.88-2.03)	0.1776	1.51 (1.09-2.09)	0.0123
IHD	1.12 (0.87-1.43)	0.3866	1.12 (0.87-1.45)	0.3700	0.93 (0.63-1.39)	0.7375	5.49 (3.60-8.36)	<.0001	1.45 (0.74-2.86)	0.2764	0.70 (0.32-1.55)	0.3791
CVD	0.93 (0.70-1.24)	0.6254	0.80 (0.59-1.08)	0.1487	0.94 (0.61-1.46)	0.7936	1.64 (0.84-3.22)	0.1484	3.48 (2.03-5.99)	<.0001	0.73 (0.30-1.73)	0.4709
Obesity	1.47 (1.18-1.82)	0.0005	1.31 (1.06-1.61)	0.0115	1.27 (0.93-1.74)	0.1271	1.04 (0.52-2.07)	0.9131	0.87 (0.40-1.93)	0.7368	5.09 (3.67-7.07)	<.0001
Female												
Any chronic conditions	1.49 (1.36-1.63)	<.0001	1.49 (1.36-1.63)	<.0001	1.39 (1.21-1.60)	<.0001	1.31 (1.01-1.71)	0.0453	0.91 (0.68-1.22)	0.5335	1.36 (1.08-1.71)	0.0101
Hypertension	1.49 (1.36-1.62)	<.0001	1.59 (1.45-1.74)	<.0001	1.26 (1.10-1.45)	0.0011	1.32 (1.02-1.71)	0.0365	0.86 (0.64-1.15)	0.3052	1.15 (0.92-1.45)	0.2201

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Diabetes	1.28 (1.12-1,46)	0.0002	1.28 (1.12-1.46)	0.0003	1.76 (1.45-2.13)	<.0001	0.95 (0.65-1.40)	0.8038	0.95 (0.60-1.49)	0.8158	1.32 (0.96-1.81)	0.0902
IHD	1.06 (0.82-1.36)	0.6716	1.01 (0.78-1.31)	0.9455	1.09 (0.75-1.59)	0.6389	5.72 (3.81-8.58)	<.0001	1.47 (0.75-2.87)	0.2645	1.03 (0.52-2.01)	0.9400
CVD	0.97 (0.74-1.26)	0.8189	0.83 (0.63-1.09)	0.1782	1.16 (0.77-1.75)	0.4648	1.43 (0.72-2.82)	0.3023	3.64 (2.19-6.08)	<.0001	0.52 (0.19-1.39)	0.1907
Obesity	1.13 (0.90-1.42)	0.2994	1.00 (0.79-1.27)	0.9974	1.52 (1.11-2.09)	0.0100	0.65 (0.28-1.50)	0.3101	0.27 (0.06-1.11)	0.0699	3.61 (2.48-5.26)	<.0001
Illieracy/Primary												
Any chronic conditions	2.29 (2.00-2.63)	<.0001	1.50 (1.31-1.71)	<.0001	1.16 (0.97-1.38)	0.1064	0.95 (0.68-1.34)	0.7815	0.95 (0.70-1.29)	0.7388	1.19 (0.85-1.67)	0.3038
Hypertension	1.77 (1.55-2.01)	<.0001	2.55 (2.22-2.92)	<.0001	1.12 (0.94-1.33)	0.2053	0.97 (0.70-1.35)	0.8688	0.99 (0.74-1.34)	0.9727	1.00 (0.72-1.38)	0.9855
Diabetes	1.20 (1.00-1.43)	0.0445	1.22 (1.03-1.44)	0.0229	1.79 (1.35-2.38)	<.0001	0.70 (0.40-1.24)	0.2242	0.77 (0.48-1.26)	0.3011	1.18 (0.72-1.93)	0.5080
IHD	1.05 (0.74-1.48)	0.7975	0.97 (0.70-1.36)	0.8720	0.86 (0.48-1.54)	0.6177	6.74 (3.64-12.46)	<.0001	2.03 (1.05-3.92)	0.0360	1.26 (0.48-3.36)	0.6389
CVD	0.94 (0.68-1.29)	0.6994	0.85 (0.62-1.17)	0.3135	0.83 (0.50-1.39)	0.4814	1.86 (0.91-3.80)	0.0883	2.73 (1.32-5.64)	0.0066	1.17 (0.49-2.81)	0.7180

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Obesity	1.20 (0.91-1.58)	0.2047	1.07 (0.81-1.40)	0.6397	1.46 (1.01-2.13)	0.0450	1.02 (0.45-2.32)	0.9649	0.62 (0.25-1.54)	0.3065	3.78 (2.04-7.01)	<.0001
Seconary												
Any chronic conditions	1.45 (1.32-1.60)	<.0001	1.43 (1.29-1.58)	<.0001	1.37 (1.20-1.58)	<.0001	1.36 (1.02-1.83)	0.0349	0.97 (0.69-1.37)	0.8698	0.98 (0.78-1.24)	0.8892
Hypertension	1.34 (1.22-1.48)	<.0001	1.91 (1.72-2.11)	<.0001	1.32 (1.16-1.51)	<.0001	1.37 (1.03-1.81)	0.0287	0.76 (0.53-1.08)	0.1227	1.00 (0.80-1.25)	0.9899
Diabetes	1.19 (1.04-1.36)	0.0090	1.29 (1.13-1.46)	0.0001	1.67 (1.34-2.08)	<.0001	1.28 (0.87-1.90)	0.2140	1.61 (1.02-2.53)	0.0395	1.40 (1.03-1.90)	0.0331
IHD	1.05 (0.82-1.33)	0.7096	1.11 (0.86-1.42)	0.4324	0.95 (0.65-1.39)	0.7949	6.06 (3.68-9.97)	<.0001	0.81 (0.32-2.06)	0.6626	0.51 (0.21-1.20)	0.1231
CVD	0.93 (0.70-1.22)	0.5950	0.83 (0.62-1.12)	0.2354	1.33 (0.90-1.96)	0.1528	0.81 (0.32-2.04)	0.6586	3.90 (1.99-7.63)	<.0001	0.24 (0.06-0.98)	0.0467
Obesity	1.32 (1.06-1.64)	0.0132	1.14 (0.92-1.41)	0.2223	1.28 (0.95-1.71)	0.1041	0.73 (0.34-1.57)	0.4245	0.67 (0.24-1.86)	0.4398	3.05 (1.94-4.79)	<.0001
Collage												
Any chronic conditions	1.69 (1.39-2.05)	<.0001	1.55 (1.25-1.91)	<.0001	1.14 (0.83-1.58)	0.4111	1.05 (0.63-1.75)	0.8497	1.12 (0.56-2.23)	0.7439	1.82 (1.25-2.67)	0.0003

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Hypertension	1.43 (1.19-1.73)	0.0002	1.64 (1.32-2.04)	<.0001	1.17 (0.85-1.61)	0.3432	0.93 (0.56-1.53)	0.7628	0.67 (0.33-1.36)	0.2673	1.62 (1.12-2.33)	0.0103
Diabetes	1.70 (1.33-2.16)	<.0001	1.60 (1.22-2.09)	0.0007	1.48 (0.91-2.42)	0.1169	1.23 (0.63-2.41)	0.5452	1.22 (0.51-2.93)	0.6546	1.69 (1.08-2.65)	0.0220
IHD	1.14 (0.75-1.73)	0.5444	1.02 (0.64-1.63)	0.9371	1.28 (0.69-2.39)	0.4309	2.41 (0.98-5.96)	0.0557	1.68 (0.58-4.87)	0.3376	1.58 (0.67-3.70)	0.2928
CVD	1.20 (0.69-2.09)	0.5079	0.72 (0.37-1.39)	0.3256	0.57 (0.20-1.62)	0.2923	2.32 (0.85-6.28)	0.0988	10.19 (3.52-29-46)	<.0001	0.88 (0.21-3.64)	0.8569
Obesity	2.34 (1.52-3.60)	0.0001	1.51 (0.94-2.42)	0.0848	1.70 (0.78-3.71)	0.1829	0.83 (0.18-3.93)	0.8179	-	-	4.93 (2.72-8.93)	<0.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, marriage status, drinking and smoking. The adjusted GEE model was not fit for estimate the association between CVD and obesity in the “Collage” subgroup.

Table S3 The crude associations of chronic conditions between children and their own parents - Scene 2 (N = 5,489 dyads)

Exposure:	Any chronic conditions		Hypertension		Diabetes		Obesity	
chronic condition status of parents	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	5.85(4.83-7.09)	<.0001	6.60(5.25-8.28)	<.0001	6.36(3.98-10.18)	<.0001	2.91(2.01-4.20)	<.0001
Hypertension	4.52(3.77-5.41)	<.0001	7.14(5.73-8.90)	<.0001	3.32(2.24-4.90)	<.0001	1.61(1.13-2.29)	0.0085
Diabetes	2.26(1.78-2.87)	<.0001	1.75(1.27-2.41)	0.0007	11.28(7.65-16.62)	<.0001	1.57(0.93-2.67)	0.0941
Obesity	3.09(2.07-4.60)	<.0001	0.82(0.39-1.73)	0.6037	1.98(0.79-4.94)	0.1449	14.88(9.35-23.68)	<.0001

Note:

The chronic conditions on the top of table represented the status of children. The chronic conditions on the left of the table represented the status of their parents. The analyses of IHD and CVD were not conducted because of low prevalence rate in this subset.

Table S4 The crude associations of chronic conditions between wife and their own husband - Scene 3 (N = 7,844 spouses)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	2.88 (2.61-3.18)	<.0001	2.80 (2.53-3.10)	<.0001	2.35 (1.96-2.82)	<.0001	3.41 (2.32-5.02)	<.0001	1.82 (1.24-2.67)	0.0022	1.65 (1.20-2.26)	0.0020
Hypertension	2.91 (2.63-3.22)	<.0001	2.94 (2.65-3.26)	<.0001	2.31 (1.93-2.78)	<.0001	3.30 (2.27-4.80)	<.0001	1.62 (1.10-2.38)	0.0147	1.39 (1.01-1.93)	0.0453
Diabetes	2.09 (1.78-2.46)	<.0001	1.97 (1.67-2.33)	<.0001	2.12 (1.64-2.75)	<.0001	2.51 (1.55-4.05)	0.0002	0.92 (0.44-1.89)	0.8143	1.20 (0.70-2.06)	0.5082
IHD	2.84 (2.01-4.01)	<.0001	2.54 (1.80-3.59)	<.0001	2.38 (1.44-3.95)	0.0008	18.21 (11.18-29.63)	<.0001	5.01 (2.39-10.53)	<.0001	1.55 (0.57-4.26)	0.3911
CVD	2.91 (2.01-4.19)	<.0001	2.18 (1.51-3.15)	<.0001	2.02 (1.15-3.55)	0.0150	3.68 (1.58-8.53)	0.0025	10.16 (5.51-18.73)	<.0001	1.75 (0.64-4.80)	0.2782
Obesity	1.02 (0.74-1.39)	0.9177	0.73 (0.51-1.04)	0.0822	1.42 (0.84-2.38)	0.1863	0.72 (0.18-2.94)	0.6484	0.39 (0.05-2.83)	0.3542	4.72 (2.7108.22)	<.0001

Note:

The chronic conditions on the top of table represented the status of wives. The chronic conditions on the left of the table represented the status of their husband.

Table S5 The results of full models for the association between chronic conditions of individual with the same condition of household member

	Subsample1		Subsample2		Subsample3	
Factors	OR(95%CI)	P	OR(95%CI)	P	OR(95%CI)	P
Any chronic conditions						
Same condition	3.03(2.81-3.28)	<0.0001	5.13(4.20-6.28)	<0.0001	1.58(1.41-1.77)	<0.0001
Age	1.07(1.07-1.07)	<0.0001	1.08(1.08-1.09)	<0.0001	1.08(1.07-1.08)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.16(1.07-1.26)	0.0002	1.48(1.17-1.88)	0.0010	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.82(0.74-0.91)	0.0001	1.02(0.62-1.68)	0.9319	1.08(0.78-1.49)	0.6577
Education status						
Illieracy/Primary	Ref					
Seconary	1.22(1.11-1.34)	<0.0001	1.54(1.07-2.21)	0.0204	1.91(1.54-2.37)	<0.0001
Collage	1.34(1.23-1.45)	<0.0001	1.44(1.13-1.83)	0.0028	1.74(1.43-2.12)	<0.0001
Smoking	1.00(0.91-1.09)	0.9306	1.19(0.92-1.53)	0.1781	1.01(0.70-1.48)	0.9386
Drinking	0.85(0.78-0.93)	0.0002	0.89(0.70-1.13)	0.3515	1.20(0.85-1.70)	0.3001
Hypertension						
Same condition	3.26(3.02-3.52)	<0.0001	6.29(4.92-8.05)	<0.0001	1.63(1.45-1.84)	<0.0001
Age	1.07(1.07-1.07)	<0.0001	1.12(1.11-1.13)	<0.0001	1.08(1.07-1.08)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.10(1.01-1.20)	0.0247	1.26(0.94-1.70)	0.1247	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.98(0.87-1.11)	0.7680	0.73(0.39-1.37)	0.3310	0.98(0.70-1.37)	0.9004
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	1.32(1.20-1.45)	<0.0001	1.56(1.01-2.41)	0.0435	1.92(1.53-2.40)	<0.0001
Collage	1.39(1.28-1.51)	<0.0001	1.50(1.10-2.03)	0.0093	1.76(1.42-2.17)	<0.0001
Smoking	1.03(0.94-1.13)	0.5309	1.13(0.84-1.53)	0.4109	1.11(0.75-1.65)	0.6052
Drinking	0.77(0.70-0.84)	<0.0001	0.71(0.54-0.94)	0.0166	1.22(0.85-1.75)	0.2834
Diabetes						
Same condition	1.68(1.40-2.01)	<0.0001	11.56(7.88-16.98)	<0.0001	1.57(1.21-2.03)	0.0007
Age	1.05(1.04-1.06)	<0.0001	1.08(1.06-1.10)	<0.0001	1.05(1.05-1.06)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.05(0.91-1.20)	0.5013	1.45(0.88-2.37)	0.1409	-	-
Health insurance status						
Insuranced	Ref		Ref			

No insuranced	0.29(0.06-1.48)	0.1362	0.94(0.30-2.93)	0.9158	0.86(0.46-1.59)	0.6258
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	1.00(0.79-1.27)	0.9867	2.34(1.04-5.27)	0.0410	2.23(1.41-3.53)	0.0006
Collage	1.35(1.17-1.55)	<0.0001	2.66(1.45-4.87)	0.0016	2.15(1.40-3.31)	0.0005
Smoking	0.84(0.73-0.96)	0.0130	1.17(0.73-1.89)	0.5071	0.72(0.41-1.29)	0.2728
Drinking	1.12(0.98-1.29)	0.0943	1.11(0.69-1.79)	0.6780	1.32(0.69-2.53)	0.4069
IHD						
Same condition	5.31(3.56-7.92)	<0.0001	-	-	6.58(3.78-11.43)	<0.0001
Age	1.06(1.05-1.07)	<0.0001	-	-	1.11(1.09-1.12)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	0.85(0.64-1.12)	0.2523	-	-	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.52(0.16-1.69)	0.2753	-	-	1.39(0.41-4.73)	0.5993
Education status						
Illieracy/Primary	Ref					
Seconary	0.60(0.43-0.84)	0.0025	-	-	0.39(0.20-0.78)	0.0072
Collage	0.87(0.70-1.10)	0.2495	-	-	0.88(0.47-1.65)	0.6853
Smoking	1.10(0.83-1.46)	0.5087	-	-	2.16(0.28-16.40)	0.4584
Drinking	1.09(0.81-1.46)	0.5672	-	-	0.42(0.18-0.98)	0.0458
CVD						
Same condition	3.40(1.99-5.80)	<0.0001	-	-	3.62(1.86-7.07)	0.0002
Age	1.08(1.07-1.09)	<0.0001	-	-	1.10(1.08-1.12)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.20(0.94-1.54)	0.1491	-	-	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.73(0.38-1.40)	0.3380	-	-	1.23(0.35-4.31)	0.7483
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	1.59(1.13-2.24)	0.0072	-	-	1.25(0.55-2.81)	0.5940
Collage	1.24(0.90-1.72)	0.1899	-	-	1.15(0.51-2.60)	0.7410
Smoking	1.34(0.97-1.84)	0.0781	-	-	1.61(0.21-12.13)	0.6429
Drinking	1.32(0.96-1.80)	0.0867	-	-	2.57(0.34-19.52)	0.3603
Obesity						
Same condition	3.41(2.34-4.96)	<0.0001	13.85(8.54-22.46)	<0.0001	5.09(2.92-8.86)	<0.0001
Age	1.01(1.00-1.02)	0.0462	1.00(0.98-1.02)	0.8932	1.02(1.01-1.04)	0.0015
Sex						
Female	Ref		Ref		-	-
Male	1.08(0.88-1.33)	0.4682	2.04(1.31-3.17)	0.0017	-	-

Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.37(0.06-2.09)	0.2588	1.18(0.55-2.53)	0.6670	1.56(0.72-3.41)	0.2630
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	0.87(0.56-1.35)	0.5298	1.08(0.44-2.64)	0.8624	2.06(0.98-4.32)	0.0558
Collage	1.04(0.81-1.34)	0.7469	1.27(0.82-1.98)	0.2858	2.11(1.06-4.20)	0.0339
Smoking	1.11(0.89-1.39)	0.3468	1.14(0.69-1.89)	0.6041	1.22(0.38-3.86)	0.7376
Drinking	1.02(0.82-1.26)	0.8914	1.47(0.83-2.58)	0.1846	0.89(0.37-2.17)	0.8004

Statistical Analysis Plan

Study design and background

From 1993 to 2013, the NHSS has been conducted for five times (every five years) which is a cross-sectional survey. The latest one was conducted in 2013, which was the fifth one. The 5th Health Service Survey of Shanghai was the extension of 5th NHSS. This survey was organized and conducted by the Shanghai Municipal Commission Health and Family Planning. The sampling method and quality assurance measures used in Shanghai survey were consistent with the national sampling approach and principle. The 5th Health Service Survey of Shanghai cover all of the 17 districts in Shanghai, and a three-stage, stratified, random sampling method was adopted. First stage, 100 towns/townships were selected randomly from all these 17 districts. Second stage, one thousand villages/communities were sampled randomly from these selected towns/townships. Third stage, about 12,000 households were identified randomly.

A face-to-face interview approach using structured household questionnaire, which was developed by the National Commission Health and Family Planning of China, was conducted for each household. The questionnaire contained the general information of household, the demographic characteristics of residents, the relationship of household members, self-reported illness and injury, outpatient and inpatient information.

To ensure the quality of this survey, some quality assurance measures were applied during the process of data collection. Logic errors would be checked among the data by survey constitutors. If there were logic errors, the investigators would contact the household members and verify the relevant information. The accuracy of data information were assessed by revisit-approach. The investigators revisited 5% of the sampled households and collected ten key questions to check the consistency of the information recorded. The consistency rates between these two visits was near to 99 %.

Objective

The aim of our study is to estimate the association between an adult's own chronic condition status and the chronic condition status of other household members.

Data management

Those who meet the following conditions will be excluded.

1. Residents less than 18 years old
2. Only one person in a household

Because the NHSS of Shanghai conducted well, there is little data missing in the data set. If one resident missed some important variables, he/she will be excluded from analyses.

Outcomes

We choose five chronic conditions with high prevalence in this survey: hypertension, diabetes, ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity. The definition of these chronic conditions is based on the question in the questionnaire,

the disease coding list of the NHSS, and Body mass index (BMI).

Hypertension: Hypertension for every resident is indicated based on the question in the questionnaire "Have you ever been told by a doctor that you have hypertension". If one choose "YES", the hypertension status of the participant is "1". If the one choose "NO", the hypertension status of the participant is "0".

Diabetes: Diabetes for every resident is indicated based on the question in the questionnaire "Have you ever been told by a doctor that you have diabetes". If one choose "YES", the diabetes status of the participant is "1". If the one choose "NO", the diabetes status of the participant is "0".

IHD: The questionnaire will record all of the chronic diseases for every resident, and these chronic diseases will been encoded in accordance with the disease coding list of the NHSS. IHD included angina pectoris (061), myocardial infarction (062), and other ischemic heart disease (063). If one choose any of these three codes, the IHD status of the participant is "1". If the one did not choose any of these three codes, the IHD status of the participant is "0".

CVD: This chronic condition will be indicated according to the disease coding list of the NHSS: cerebrovascular disease (067). If one choose this code, the CVD status of the participant is "1". If the one did not choose this code, the CVD status of the participant is "0".

Obesity: Body mass index (BMI) will be calculated for every resident by height and weight. Obesity was indicated by the World Health Organization (WHO) International BMI categories (BMI $\geq$ 30 kg/m^2). If the BMI of the one is equal or over 30 kg/m^2, the obesity status of the participant is "1". If the BMI of the one is lower than 30 kg/m^2, the obesity status of the participant is "0".

Any chronic conditions: If any of these five chronic conditions is "Yes" for a participant, his or her status of "Any chronic conditions" is "Yes", otherwise "Any chronic conditions" is "No"

Covariates

Socio-demographic characteristics added to our models as covariates include age (continuously specified in years), education status (illiteracy/primary, secondary or college), health insurance status (yes or no), marriage status (married, unmarried, divorced or widowed), smoking (yes or no), and drinking (yes or no). Except the analyses of spouse subsample, gender (male or female) and is also included as a covariate.

Subsamples

To make a comprehensive estimation for the association, we conduct the analyses in three subsamples: all adult household members, adult children, and wives.

Subsample 1 all adult household members: We can estimate the general association between an adult's own chronic condition status and the chronic condition status of other household members based on this subsample. The chronic condition status of participant is treated as outcome, and the household situation of chronic condition for each participant is treated as exposure factor. If any other residents (excluding self)

have the given chronic conditions, the exposure for the one is "YES".

Subsample 2 adult children: We only include adult children (age > 18 years old) in this subsample, and those participants are excluded if the disease information of parents were not available. The chronic conditions status of their parents are considered as exposure, and the chronic condition status of adult children is treated as outcome. If any of the one's parents have the given chronic conditions, the exposure for the one is "YES". The results of this subsample might show the effect of genetic factors and common living environment in the relationships that we are interested in.

Subsample 3 wives: we include married women in the analyses. We define the chronic condition of wife as the outcome and the chronic condition of husband as the exposure. The results of this subsample might show the effect of common living environment without genetic ties in the relationships that we are interested in.

Statistical analysis

Descriptive analyses

Descriptive statistics are summarized for the covariates of three subsamples, respectively. Mean (standard deviation, SD) is calculated for continuous variables, and counts (percentages) are calculated for categorical variables.

Generalized Estimating Equations

The generalized estimating equations (GEE) model with logit link will be used to find out the relationship between one's chronic conditions and the others with chronic conditions living in the same household. We consider two-level hierarchical structure of the model (individual within household), and choose the exchangeable working correlation matrix for GEE model. The GEE model is performed using "GENMOD" procedure in SAS software. The analyses model is based on individual's data without considering sampling weight, because there is no relevant information.

The adjusted GEE models will include age, gender, health insurance status, education status, drinking and smoking (gender is excluded in the third subsample). The chronic condition status of participants is included in models as independent variable. And the exposure (status of other members) is included in models as dependent variable. The final conclusion will be based on the results of the adjusted models.

The odds ratio (OR) and 95% confidence interval (CI) are estimated by GEE model to indicate the association between any chronic condition or each given chronic condition of individual with the same condition of household member (e.g., the association between the hypertensive status of a participants and that same condition in his or her other household members). And the association of different chronic condition will also be assessed (e.g., the association between hypertension in a participant and diabetes in other household members).

Sensitivity analysis

We will also estimate the unadjusted odds ratio and 95% confidence interval as sensitivity analysis. And the unadjusted results are required by the STROBE checklist.

Subgroup analysis

We plan to perform two subgroup analysis. One is by gender (male or female) and the

other is by education status (illiteracy/primary, secondary or collage). Illiteracy/primary means the education years were from 0 to 5 years, secondary means the education years were from 6 to 12 years, and collage means the education years of residents were higher than 12 years including undergraduate and graduate degrees. The reason why we perform this two subgroup analysis is this two factors may have a significant influence on living habits which is the cause of chronic conditions.

Other information

All data management and statistical analyses will be performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC). All reported p values are two-sided and p value < 0.05 is regarded as statistically significant. This study will be reported according to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.

Supplementary S1 The STROBE checklist

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Check	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes. We had indicated that this study is a cross-sectional study in title.	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes. These information was listed in "Abstract".	Page 2
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes. The research about the concordance of chronic conditions among the household members could cause people and health management department to pay attention to the effect of co-residence factor in the prevalence of some chronic diseases.	Page 3
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes. We did effort to test and explore the hypothesis that whether one's chronic conditions are related to the others with chronic conditions living in the same household.	Page 4
Methods				
Study design	4	Present key elements of study design early in the paper	Yes. The data for this study was from the fifth Health Service Survey of Shanghai in 2013 (the extension of China's National Health Service Survey-NHSS), and this is a cross-sectional survey study.	Page5 - Page6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes. This health survey was conducted in Shanghai, China, in 2013. Details could be found in "Data source" section.	Page 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Yes. In our study, we included the households with at least two adults who aged 18 or older.	Page 6
Variables	7	Clearly define all outcomes, exposures,	Yes. We chose five chronic	Page 6

		predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	conditions with high prevalence: hypertension, diabetes, Ischemic heart disease (IHD), cerebrovascular disease (CVD), obesity. Details could be found in "Five chronic conditions" section.	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes. These five chronic conditions were from the self-reported records in the questionnaires, and we chose these diseases according to the disease coding list of the NHSS.	Page5 - Page6
Bias	9	Describe any efforts to address potential sources of bias	Yes. Some socio-demographic characteristics would be included in our analyses as covariates: Age, gender, education status, marriage status, health insurance status, smoking, drinking.	Page 7
Study size	10	Explain how the study size was arrived at	Yes. A total of 10,198 households (27,014 participants) with at least two adults who aged 18 or older were included in our study, and details could be found in figure 1.	Page8 – Page9, Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes. Then the generalized estimating equations (GEE) model with logit link would be used to find out the relationship between one's chronic conditions and the others with chronic conditions living in the same household. And we would estimate these associations in three different household scenes: all household members, dyads of parents and children, and spouses.	Page 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for	Yes. Then the generalized estimating equations (GEE)	Page 8

		confounding	model with logit link would be used in our study with adjusting for age, gender, health insurance status, education status, marriage status, drinking and smoking.	
		(*b*) Describe any methods used to examine subgroups and interactions	Yes. The subgroup analyses would be conducted in all household members scene according to two pre-defined stratification factors: sex (male or female), education (illiteracy/primary, secondary, and college).	Page 8
		(*c*) Explain how missing data were addressed	Yes. We did not conducted any statistical model to deal with the missing data because of low missing data rate. The observation with missing data would be excluded from the final analyses.	Page 8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Yes. The GEE model would be applicable to household data.	Page 8
		(*e*) Describe any sensitivity analyses	Yes. We also conducted crude GEE models to find out the relationship.	Page 8
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes. The details could be found in the first paragraph of "Results" and figure 1.	Page 8 – Page 9, Figure 1
		(b) Give reasons for non-participation at each stage	Yes. The details could be found in the first paragraph of "Results" and figure 1.	Page 8 – Page 9, Figure 1
		(c) Consider use of a flow diagram	Yes. The figure 1 is a flow diagram.	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes. The details could be found in the first paragraph of "Results" and table 1.	Page 9, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Yes. The details could be found in the first paragraph of "Results" and figure 1.	Page 8 – Page 9, Figure 1

Outcome data	15*	Report numbers of outcome events or summary measures	Yes. The details could be found in table 1.	Table 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Yes. The final conclusion was based on the results of the adjusted models. The results of adjusted model were listed in table 2-4, and those of crude model were available in the supplemental tables.	Table 2 – 4
		(*b*) Report category boundaries when continuous variables were categorized		
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes. The results of subgroup analyses were shown in figure 2 and supplemental table S2.	Figure2 & Table S2
Discussion				
Key results	18	Summarise key results with reference to study objectives	Yes. We found that the participants who live with the household members with chronic conditions were associated with 46% higher OR of having one or more chronic condition. For these five chronic conditions, the above relationship was observed in each same chronic condition.	Page 11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes. We discussed four points of limitation in the "Discussion" section.	Page 14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes. The evidence about the effect of co-residence factor in some chronic conditions would suggest that people should pay more attention to their health status, especially those whose household members have chronic conditions. And the mechanisms about these associations should be investigated by further research.	Page 13 – Page 14

Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes. The relationships of chronic conditions among the household members were consistent in three different scenes and subgroups.	Page 13 – Page 14
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	This study was conducted under a grant from the Fourth Round of Shanghai Three-year Action Plan on Public Health Discipline and Talent Program: Evidence-based Public Health and Health Economics(No. 15GWZK0901).	Page 16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The concordance of chronic conditions among the household members in Shanghai: a cross-sectional study

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The concordance of chronic conditions among the household members in Shanghai: a cross-sectional study

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Abstract

Objectives: Members living in the same household tend to share some similar behaviors and environment. We want to quantitatively assess the associations of chronic conditions to investigate the concordance of disease status among the household members.

Setting: Shanghai, China.

Participants: Our data was from the fifth Health Service Survey in Shanghai in 2013. 12,002 households with 31,531 residents were selected in this survey by using a three-stage, stratified, random sampling method.

Outcome measures: Five highly prevalent chronic conditions, namely hypertension, diabetes, ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity were chosen. The generalized estimating equations (GEE) model was used to estimate the associations adjusted for age, gender, education status, health insurance status, smoking, and drinking. Using a subsample of adult children with parents' chronic conditions as the key risk factor and a subsample of wives with the chronic conditions of the husband as key risk factor, we reran our GEE models to explore chronic condition concordance within these relationships.

Results: A total of 10,198 households with 27,010 adult participants were included. Using all adult household members, we found positive statistically significant associations between one's chronic conditions and the same disease status of their household members (hypertension [odds ratio (OR) = 3.26, 95% confidence interval (CI): 3.02-3.52]; diabetes [OR = 1.68, 95% CI: 1.40-2.01]; IHD [OR = 5.31, 95% CI: 3.56-7.92]; CVD [OR = 3.40, 95% CI: 1.99-5.80]; and obesity [OR = 3.41, 95% CI: 2.34-4.96]). The results of analyzing ad-child subsample and spouse subsample also showed similar associations. Moreover, the potential concordance of different chronic conditions was found between hypertension and diabetes.

Conclusions: We found chronic condition concordance within households. This study provides evidence that the chronic conditions of other members of a household may be a significant risk factor for a household member's own health.

Strength & Limitations:

- This is the first study in China to estimate the risk to a household member's own health, which associate with the chronic conditions of other household members.
- We perform multivariate logistic GEE models to estimate the association between an adult's own chronic condition status and the chronic condition status of other household members within three subsamples including all adult household members, children with parents' chronic conditions as key risk factor, and wives with husband's chronic conditions as key risk factor.
- The definition and diagnosis of chronic condition for each participant was based on his or her self-reported records.
- This study was conducted in Shanghai and the results might not be generalized to other regions of China.
- Based as it is on cross-sectional data, this study does not estimate the risk of a new chronic condition in a household member, nor does it provide evidence of a causal relationship.

Key words: chronic conditions; household; concordance

Background

During the past three decades, China had experienced rapid social, economic and health services development[1 2]. Life expectancy has increased, lifestyles have changed, health care has become more accessible, and health insurance coverage has increased. Aligned with these remarkable improvements, healthcare concerns in the country have expanded from a narrow focus on infectious diseases to encompass treatment for non-communicable chronic conditions as well [2-4]. Research has shown the prevalence of hypertension increased from 5.11% in 1959 to 17.65% in 2002, and the prevalence of type 2 diabetes mellitus increased from 1% in 1980 to 9.7% in 2008[5-7]. In measuring disability-adjusted life-years (DALYs), non-communicable chronic conditions have become main contributors to a country's burden of disease. As of 2015, high systolic blood pressure, high fasting plasma glucose, and high body mass index respectively ranked 1st, 2nd, and 4th as important risk factors related to DALY. In 1990, the respective ranks of these three diseases were only 3rd, 10th and 13th.[8] As a typical city in China, Shanghai represents the direction of economic and healthy development in China. Noteworthily, aging is a significant issue in Shanghai. Moreover, this would bring about the new healthcare challenges for Chinese society and government[9].

Improvement in health care and innovation of new effective medical treatments will definitely play an increasingly important role in dealing with chronic conditions. Additionally, detection of risk factors and identification of individuals at high-risk are the important first steps in the prevention and treatment of chronic conditions. To study the risk factors, various research has mainly focused on the personal lifestyles related to the risk of chronic conditions, for example smoking, drinking, exercise, and diet[10-13]. Some genetic mechanisms are also considered as the risk factors of chronic conditions[14 15]. The household environment, which integrate the lifestyles, genetic mechanisms and environmental factors, would be an important research direction in controlling the

prevalence of chronic conditions[16].

Based on the fifth Health Service Survey of Shanghai, which was the extension of China's National Health Service Survey (NHSS) in 2013, the prevalence rate was 27.24% for hypertension and 7.05% for diabetes among 29,269 people aged 15 or older[17]. Regarding hypertension, 6,096 out of 12,002 households (50.79%) had at least one member with hypertension, and 1,733 households (28.43%) of these 6,096 households had at least two members suffering from the disease. This result showed the possibility of household clustering in the prevalence of chronic conditions. We hypothesized that there were associations between chronic conditions in the participants and the same conditions in their household members, we conducted the research and analyses using data from the fifth Health Service Survey of Shanghai. In this study, we focused on five highly prevalent chronic conditions: hypertension, diabetes, Ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity. Risk factors based on chronic conditions in other family members were detected for subsamples consisting of all household members, adult children, and wives, respectively.

Methods

Data source

In this study, we used data from the fifth Health Service Survey of Shanghai in 2013. This survey was organized and conducted by the Shanghai Municipal Commission Health and Family Planning, and was the extension of NHSS. From 1993 to 2013, the NHSS has been conducted for five times (every five years), and is a cross-sectional survey study[18]. The sampling method and quality assurance measures used in Shanghai survey were consistent with the national sampling approach and principle[19]. The fifth Health Service Survey of Shanghai was conducted in all of the 17 districts in Shanghai. The survey adopted a three-stage, stratified, random sampling method. In the first stage,

100 towns/townships were randomly selected from all these 17 districts. In the second stage, one thousand villages/communities were randomly sampled from the selected towns/townships. In the third stage, about 12,000 households were randomly selected. We conducted a face-to-face interview with each household using a structured household questionnaire developed by the National Commission Health and Family Planning of China. The questionnaire contained the general information of the households, the demographic characteristics of household members, relationships among them, their self-reported illnesses and injuries, as well as their outpatient and inpatient information.

To ensure the quality of this survey, certain assurance measures were applied during the process of data collection. Survey constitutors checked potential logic errors of the collected data. In case of any logic errors, the investigators would contact the household members and verify the relevant information. The accuracy of data information was assessed using the revisit approach. More specifically, the investigators revisited 5% of the sampled households and collected ten key questions to check the consistency of the information recorded. The consistency rate between these two visits was nearly 99 %. Additionally, the Myer's Blended index was 7.39, indicating that there was non-existence of age preference in this survey[17 20]. Finally, this survey collected the information of 12,002 households with 31,531 participants. We included the households with at least two adults aged 18 years or older.

Five chronic conditions

In this survey, we chose five chronic conditions with high prevalence rates: hypertension, diabetes, IHD, CVD, and obesity. The definition of these chronic conditions were based on the corresponding questions in the questionnaire, the disease coding list of the NHSS, and Body mass index (BMI). If a participant chose "YES" or

a specific disease code, he or she was considered to have the corresponding chronic condition.

Hypertension: Hypertension was indicated based on the question "Have you ever been told by a doctor that you have hypertension?" in the questionnaire.

Diabetes: Diabetes was indicated based on the question "Have you ever been told by a doctor that you have diabetes?" in the questionnaire.

IHD: The disease codes for IHD included angina pectoris (061), myocardial infarction (062), and other ischemic heart disease (063).

CVD: The disease code for CVD included cerebrovascular disease (067).

Obesity: Obesity was indicated by the World Health Organization (WHO) International BMI categories (BMI $\geq$ 30 kg/m^2)[21].

Covariates

Socio-demographic characteristics added to our models as covariates include age (continuously specified in years), education status (illiteracy/primary, secondary or college), health insurance status (yes or no), marriage status (married, unmarried, divorced or widowed), smoking (yes or no), and drinking (yes or no). Except the analyses of spouse subsample, gender (male or female) was also included as a covariate.

Statistical analyses

This study had five primary outcomes, each of which represented the status of each of the five chronic conditions, namely hypertension, diabetes, IHD, CVD, and obesity, in the participants ("No" or "Yes"). If a participant had any of these five chronic conditions ("Yes"), his or her status of having "Any chronic condition" is considered as "Yes". To make a comprehensive assessment, we settled three subsamples: all adult household members (the total sample), adult children (adult children subsample), and

wives (spouse subsample). In addition, we identified chronic conditions in the other household members as the exposure (or risk factor) in three subsamples.

For the full study sample of all adult household members, we included all household members aged 18 years or older. If any other residents (excluding self) have the given chronic conditions, the exposure status of household situation for each participant is identified as "Yes". For the subsample of adult children, only adult children would be included in analyses, and those participants were excluded if the disease information of parents were not available. The chronic conditions status of their parents were considered as exposure. For the subsample of spouses, we included married women in the analyses. We defined the chronic conditions of wives as the outcomes and the chronic conditions of husbands as the exposure.

The generalized estimating equations (GEE) model with logit link would be used to explore the associations between chronic conditions of participants and the conditions of the others living in the same household. We considered a two-level hierarchical structure of the model (individuals within households). The model was based on individual's data without taking sampling weight into account due to the lack of relevant information. The odds ratio (OR) and 95% confidence interval (CI) were estimated by the GEE model to indicate the association between any chronic condition or each given chronic condition of an individual and the same condition of household member (e.g., the association between the hypertensive status of a participants and that same condition in his or her other household members). In addition, the association of different chronic conditions would also be assessed (e.g., the association between hypertension in a participant and diabetes in other household members).

Adjusted models and unadjusted models were both used to estimate the associations in three household subsamples. The adjusted models included age, gender, health insurance status, education status, drinking and smoking; however, gender was

excluded in the subsample of spouses. The final conclusion was based on the results of the adjusted models. The results of unadjusted models are given to provide supplemental information. We chose the exchangeable working correlation matrix to estimate standard errors of coefficients in the GEE models.

The subgroup analyses were conducted for the full study sample of all adult household members according to two pre-defined stratification factors: sex (male or female), education (illiteracy/primary, secondary, and college). We did not conducted any statistical model to deal with the missing data because of low missing data rates. Any observation with missing data would be excluded from the final analyses. All data management and statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC). All reported p values were two-sided and p value < 0.05 was regarded as statistically significant. This study was reported based on the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines (supplementary S1), and all analyses were conducted according to the statistical analysis plan (supplementary S2).

Patient and public involvement

This is a cross-sectional study based on survey responses. It includes no further patient involvement.

Results

A total of 10,198 households (27,010 participants) with at least two adults who aged 18 years or older were included in our study from the database of the fifth Health Service Survey of Shanghai in 2013. For the subsample of adult children, there were 5,489 available records, and for the subsample of spouses, there were 7,844 records. The detail information was shown in flowchart (Fig. 1). Table 1 has shown the details of

socio-demographic characteristics. The mean age of all included participants was 52.63 years, and 31.34% (n=8,467) had at least one chronic condition. However, the adult children participants in the subsample of adult children were young (36.01 years), and the prevalence rates of chronic conditions were much low (11.89%).

All household members

In the full study sample of all adult household members, the results indicated that the chronic conditions of participants was associated with the same conditions of others living in the same household (the diagonal of Table 2): any chronic condition (OR =3.03, 95% CI: 2.81-3.28), hypertension (OR =3.26, 95% CI: 3.02-3.52), diabetes (OR = 1.68, 95% CI: 1.40-2.01), IHD (OR = 5.31, 95% CI: 3.56-7.92), CVD (OR = 3.40, 95% CI: 1.99-5.80), and obesity (OR = 3.41, 95% CI: 2.34-4.96). The results also revealed that there were significantly positive associations for some different chronic conditions (diabetes and hypertension, diabetes and obesity). The OR was 1.19 (95% CI: 1.08-1.32) for diabetes to hypertension and 1.23 (95% CI: 1.11-1.36) for hypertension to diabetes. The OR was 1.36 (95% CI:1.08-1.73) for diabetes to obesity and 1.36 (95% CI: 1.09-1.70) for obesity to diabetes. More details s were presented in Table 2, and the results of unadjusted GEE models were listed in the Table S1.

In subgroup analysis, we found the similar associations for the sex subgroups and education level subgroups (Fig. 2, Fig. 3 and Table S2). However, no significant association was not found in the analyses of diabetes and IHD in the college education subgroup.

Adult children subsample

We did not conduct the analyses of IHD and CVD in this household subsample because of low prevalence rates (0.2% for IHD, and 0.15% for CVD). Table 3 listed the results of adjusted GEE models for adult children. The positive associations between chronic conditions of adult children and the same conditions of their parents were observed:

any chronic condition (OR = 5.13, 95% CI: 4.20-6.28), hypertension (OR = 6.29, 95% CI: 4.92-8.05), diabetes (OR = 11.56, 95% CI: 7.88-16.98), and obesity (OR = 13.85, 95% CI: 8.54-22.46). For different chronic conditions, the children with diabetes and obesity were associated with parents with hypertension (OR was 2.40 for diabetes, and OR was 1.69 for obesity). And the results also indicated that hypertension status of children was associated with the diabetes status of their parents (OR = 1.61). The results of unadjusted GEE models for the subsample of adult children were listed in the Table S3.

Spouses subsample

The results of the spouses subsample are shown in the Table 4. Similar to the other two subsamples above , positive statistically significant associations were also observed between chronic conditions in husbands and the same conditions in their spouses: any chronic condition (OR = 1.58, 95% CI: 1.41-1.77), hypertension (OR = 1.63, 95% CI: 1.45-1.84), diabetes (OR = 1.57, 95% CI: 1.21-2.03), IHD (OR = 6.58, 95% CI: 3.78-11.43), CVD (OR = 3.62, 95% CI: 1.86-7.07), and obesity (OR = 5.09, 95% CI: 2.92-8.86). The wives with diabetes and IHD were associated with the hypertension status of their husbands (OR was 1.46 for diabetes, and OR was 1.60 for IHD). And the association between the hypertension status of wives and the diabetes status of husbands was also indicated (OR = 1.29). The information of unadjusted GEE models could be available in Table S4.

Discussion

In China, Shanghai has the heaviest burden of noncommunicable diseases because of its largest population and ageing population[22]. We conducted in-depth analyses of the associations among five pre-selected chronic conditions status within the household members in Shanghai, China. Using the data of the fifth Health Service Survey, we

found that the participants living with their household members with chronic conditions were associated with 46% higher OR of having one or more chronic conditions. For each of five chronic conditions, the above associations were observed in each same chronic condition. We also found the similar associations in children subsample and spouses subsample. These results were consistent with some other research results[16 23-25]. Additionally, the results suggested potential associations between the different chronic conditions, for example hypertension and diabetes.

We chose five chronic conditions (hypertension, diabetes, IHD, CVD, and obesity) as the target diseases of our study because of the highest prevalence rates in this health service survey. Based on the current knowledge, the incidence of the chronic conditions is the result of the combination of multiple factors. The members of the same household would live in the same environment, and might have the similar behaviors. In addition, some of them would have genetic associations (e.g. parents and children, or brothers and sisters). Some research reported the association between the family health history and risk of disease[26-28]. However, if a member of the household was diagnosed with a certain type of chronic condition, the likelihood of the other family members having their diagnostic tests performed was higher. This phenomenon might cause reporting bias and lead to the association of chronic conditions among household members. Our study pointed out the positive associations between chronic conditions in adults and the same conditions in their household members. According to the results of all household members, we found that the ORs for IHD and CVD were high, and the 95% CI of the corresponding ORs was wide. An explanation might be that the prevalence rates of IHD and CVD were only 1.68% and 1.38%, respectively. Moreover, low prevalence rates might reduce the accuracy of the statistical model estimation. However, the results of both the adjusted GEE model and the unadjusted one showed the positive associations for these two chronic conditions.

In order to further explore the effect of a common genetic factor or a common living environment, we analyzed two subsamples, a subsample of adult children to exam the two factors together, and a subsample of spouses to exam living environment factors in the absence of a common genetic link. Similar to results using all adult household members, positive associations were found in these two subsamples. These findings were consistent with some previous studies[23-25 29 30]. The results of analyses in these two special subsamples showed the effects of genetic factors and those of a common living environment without genetic ties on the associations of interest. Moreover, the adjusted ORs in analyses about children subsample were much higher (e.g. OR = 6.12 for hypertension association). However, we could make a conclusion that the effect of genetic factors was much more important. This might be because certain chronic conditions are age-related diseases, and the prevalence rates of adult children in this health service survey were low. For example, the prevalence of hypertension among adult children was only 8.86% (the mean of age was 39.16 years old), and prevalence rate for those whose parents had no hypertension was much lower (only 3.34%, the mean of age was 34.36 years old). Based on this consideration, we included the age covariate into the adjusted model. Therefore, these results might reflect the associations between chronic conditions in children and those in their parents despite high ORs. In order to show the effects of covariates more clearly, we listed the results of full models for three subsamples in the Table S5. We found that the effects of most covariates were consistent across three subsamples.

In addition to explore the association of the same chronic condition between participants and their household members, the results of different chronic conditions indicated that there was positive association between hypertension and diabetes. This association was seen in all three subsamples. The mechanisms and pathways could not be concluded in our study, but certain previous studies might provide some hypotheses.

The hypertension and diabetes are the syndromes of metabolic syndrome (MetS). Some risk factors for MetS, such as lifestyle, diet, family disease history, environment, might be the co-factors for the prevalence of hypertension and diabetes[31-33]. However, the exact mechanisms should need further investigation.

Although the aim of our study is not to investigate certain specific risk factors for the prevalence of chronic conditions, the quantitative assessment showed the concordance of chronic conditions within households. We suggested that individuals whose household members had certain chronic conditions should pay more attention to their health status. Health education about chronic diseases and breaking some potential unhealthy behaviors might help reduce the prevalence rates of chronic conditions among those individuals. Moreover, regular health examination (e.g. measurement of blood pressure and weight) would be helpful for residents to monitor their own health status. Shanghai is the biggest and most developed city in China, and lends the development trend. Some researchers indicated that Shanghai Chronic Disease Self-Management Program (CDSMP), the most widely accepted self-management patient education programmer worldwide, could improved participants' health behavior, self-efficacy, and health status[22]. Maybe this program could be modified and acceptable to the healthy residents whose household members have chronic conditions. Moreover, the chronic condition concordance within households should also be given special care in other regions of China, and the relevant solutions should be worked out advanced. These would be beneficial for controlling the prevalence rate of chronic conditions and reducing the disease burden for the country and among residents.

Our study had several potential limitations. First, the definition and diagnosis of chronic condition for each participant was based on his or her self-reported records. This might lead to the potential risk of underreporting and misreporting. However, this survey was part of the NHSS and every investigator had undergone rigorous and formal training.

Previous research has shown the agreement between biomedical and self-reported measurements of certain chronic conditions in a Chinese national community sample[34]. Therefore, the records of these five chronic conditions would be reliable. Second, this study was conducted in Shanghai and the results could not represent the situation in other regions of China. Nevertheless, it could draw the attention of the public and health management departments to this problem. Third, our study could neither estimate the risk of new chronic conditions among household members nor find out a certain significant risk factor. We only pointed out the phenomenon that there were associations for the prevalence of chronic conditions at the household level. The mechanism and specific causes of cohabitation effects on prevalence of chronic conditions could not be presented by our study. These results suggested that we'd better pay attention to the health status of the health residents in the households with members with chronic conditions. Fourth, this study is a cross-sectional survey study, and several potential bias, such as recall bias, confounding bias and reporting bias, might not be completely avoided. The exclusion of households with only one family member might also cause some selection bias. To deal with the confounding bias, we conducted the analyses using the adjusted GEE models with some socio-demographic covariates.

Conclusions

In conclusion, our study indicated that one's chronic condition status was associated with the status of their household members in the Shanghai, China. The results of adult children and spouses subsamples were consistent with those of all household members. Additionally, analyses about different chronic conditions suggested possible positive associations between hypertension and diabetes. The mechanisms about these associations should be investigated by further research. However, the evidence about

the association of chronic conditions for the same household members suggests that people should pay more attention to their health status, especially those whose household members have chronic conditions. That might reduce the prevalence and increase the early detection rate about some chronic conditions.

List of abbreviations

IHD = ischemic heart disease

CVD = cerebrovascular disease

GEE = generalized estimating equations

OR = odds ratio

CI = confidence interval

DALYs = disability-adjusted life-years

NHSS = National Health Service Survey

BMI = body mass index

WHO = World Health Organization

STROBE = Strengthening the Reporting of Observational studies in Epidemiology

MetS = metabolic syndrome

CDSMP = Chronic Disease Self-Management Program

Declarations

Ethics approval and consent to participate

This cross-sectional questionnaire survey was organized by the Shanghai Municipal Commission Health and Family Planning. As we knew, this survey didn't contain any treatment, blood drawing or others intervention which might influence the health of participators. Informed consent was obtained by surveyors prior to data collection and personal information was with strict conservation during our analysis process. Thus no

ethical approval is required for our study.

Data sharing

No.

Data availability statement

Data are available upon reasonable request.

Competing of interest

The authors declare that they have no competing interests.

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Authors' contribution

Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Jia He designed this study. Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Cheng Wu analysized the data. Prof. Qian He and Dr. Xinji Zhang checked the statistical analysis. Dr. Yibin Guo and Dr. Yingyi Qin wrote the manuscript. Mrs. Yuanjun Tang, Dr. Yingyi Qin, Dr. Yibin Guo and Prof. Jia He revised this manuscript.

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Figure legends

Figure 1 The flow chart of participates selection of the three subsamples analysis

Figure 2 The forest plot of five chronic conditions subgroup analysis categorized by gender. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

Figure 3 The forest plot of five chronic conditions subgroup analysis categorized by education status. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

Table 1 Socio-demographic characteristics of participants

Characteristic	All household members	Children[a]	Wives[b]
No. of households	10,198	4,865	7,211
No. of participates	27,014	5,493	7,845
Age, years, mean (SD)	52.63(17.06)	36.01(12.18)	54.01(13.85)
Male, n (%)	13,182(48.8)	3,273(59.58)	-
Education status, n (%)[c,e]			
Illieracy/Primary	5,801(21.47)	334(6.08)	2,191(27.93)
Secondary	14,484(53.62)	2,481(45.17)	4,551(58.01)
Collage	6,727(24.9)	2,678(48.75)	1,102(14.05)
Marriage status, n (%)[f]			
Unmarried	3,124(11.56)	2,286(41.62)	-
Married	22,116(81.87)	2,924(53.23)	-
Divorced or widowed	1,772(6.56)	283(5.15)	-
Insurance, n (%)	26,011(96.29)	5,247(95.52)	7,575(96.56)
Drinking, n (%)	5,157(19.09)	944(17.19)	222(2.83)
Smoking, n (%)	6,392(23.66)	1,460(26.58)	166(2.12)
Chronic conditions, n (%)			
Any chronic conditions[d]	8,467(31.34)	653(11.89)	2,414(30.77)
Hypertension	7,245(26.82)	480(8.74)	2,102(26.79)
Diabetes	1,875(6.94)	110(2)	498(6.35)
IHD	455(1.68)	11(0.2)	117(1.49)
CVD	372(1.38)	8(0.15)	106(1.35)
Obesity	631(2.34)	128(2.33)	156(1.99)

Notes:

a The characteristics of children in parents-children subsample.

b The characteristics of wives in spouses subsample.

c "Illieracy/Primary" in education status means the education years were from 0 to 5 years, "secondary" means the education years were from 6 to 12 years, and "collage" means the education years of residents were higher than 12 years including undergraduate and graduate degrees.

d The participants had at least one chronic condition.

IHD: Ischemic Heart Disease; CVD: Cerebrovascular Disease.

e There were 2 participates missing in education status in data set.

f There were 2 participates missing in marriage status in data set.

Table 2 The adjusted associations between one's chronic conditions and the disease status of their own household members - Scene 1 (N = 27,010)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	3.03 (2.81-3.28)	<0.0001	1.46 (1.34-1.58)	<0.0001	1.25 (1.12-1.39)	<0.0001	1.23 (1.00-1.51)	0.0467	0.96 (0.77-1.19)	0.6906	1.29 (1.09-1.53)	0.0034
Hypertension	1.26 (1.17-1.37)	<0.0001	3.26 (3.02-3.52)	<0.0001	1.23 (1.11-1.36)	<0.0001	1.15 (0.94-1.40)	0.1742	0.84 (0.68-1.04)	0.1177	1.02 (0.86-1.20)	0.8257
Diabetes	1.38 (1.25-1.52)	<0.0001	1.19 (1.08-1.32)	0.0005	1.68 (1.40-2.01)	<0.0001	1.06 (0.79-1.42)	0.6846	1.10 (0.80-1.50)	0.5632	1.36 (1.08-1.73)	0.0099
IHD	1.08 (0.90-1.30)	0.3911	1.07 (0.88-1.29)	0.5015	1.00 (0.75-1.33)	0.9949	5.31 (3.56-7.92)	<0.0001	1.46 (0.90-2.35)	0.1224	0.90 (0.54-1.50)	0.6846
CVD	0.95 (0.77-1.16)	0.5856	0.81 (0.66-1.00)	0.0526	1.03 (0.76-1.40)	0.8473	1.51 (0.93-2.43)	0.0951	3.40 (1.99-5.80)	<0.0001	0.60 (0.31-1.15)	0.1251
Obesity	1.40 (1.18-1.66)	0.0001	1.06 (0.90-1.25)	0.4697	1.36 (1.09-1.70)	0.0076	0.86 (0.51-1.45)	0.5663	0.58 (0.29-1.15)	0.1172	3.41 (2.34-4.96)	<0.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, drinking and smoking.

Table 3 The adjusted associations of chronic conditions between children and their own parents - Scene 2 (N = 5,489 dyads)

Exposure:	Any chronic conditions		Hypertension		Diabetes		Obesity	
chronic condition status of parents	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	5.13(4.20-6.28)	<.0001	5.58(4.34-7.17)	<.0001	4.66(2.90-7.48)	<.0001	3.02(2.07-4.42)	<.0001
Hypertension	3.93(3.25-4.75)	<.0001	6.29(4.92-8.05)	<.0001	2.40(1.61-3.57)	<.0001	1.69(1.17-2.44)	0.0056
Diabetes	2.16(1.66-2.81)	<.0001	1.61(1.16-2.25)	0.0047	11.56(7.88-16.98)	<.0001	1.51(0.88-2.57)	0.1346
Obesity	5.23(3.24-8.45)	<.0001	1.00(0.45-2.21)	0.9951	2.47(0.95-6.42)	0.0639	13.85(8.54-22.46)	<.0001

Note:

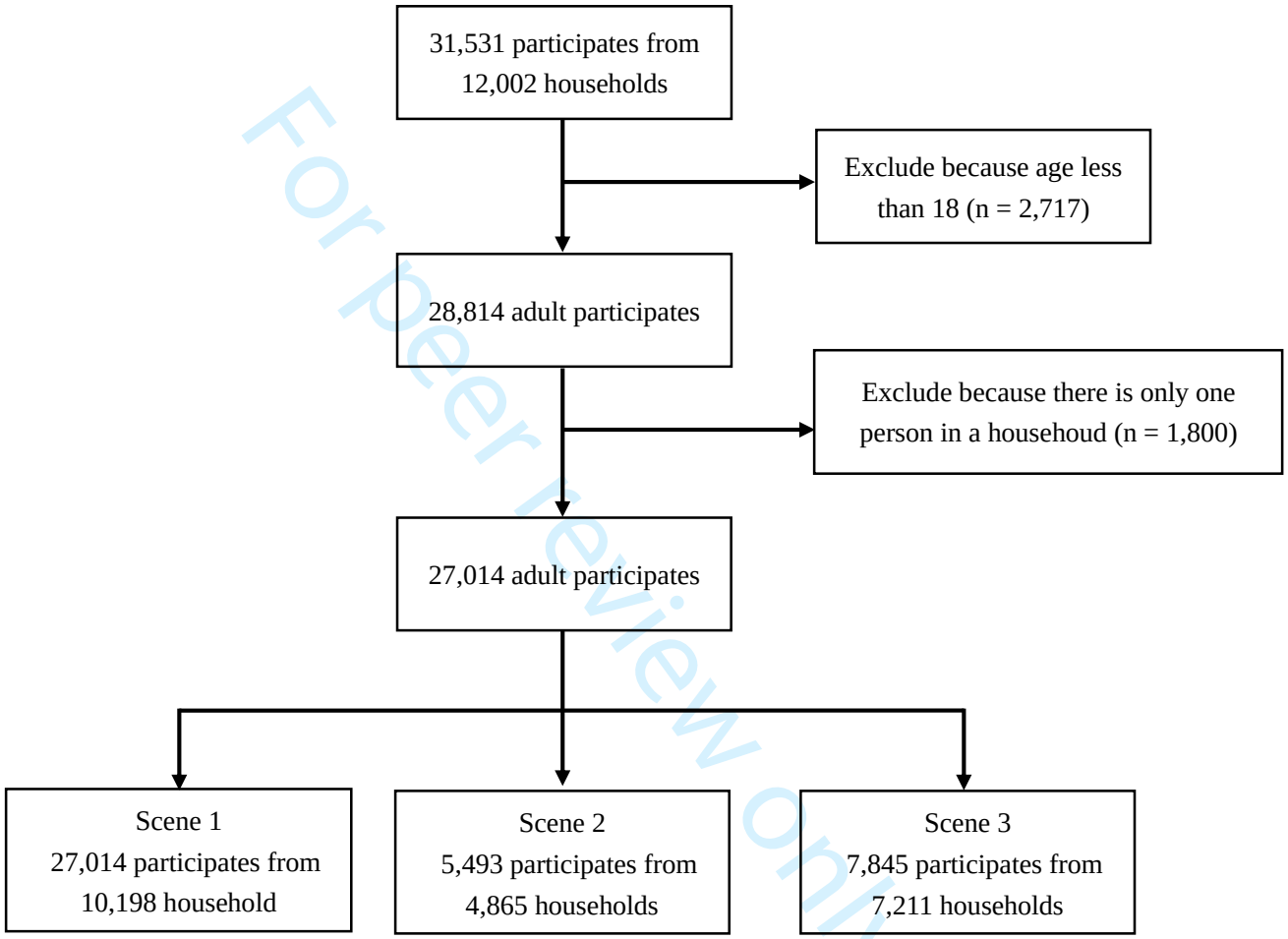
The chronic conditions on the top of table represented the status of children. The chronic conditions on the left of the table represented the status of their parents. The analyses of IHD and CVD were not conducted because of low prevalence rate in this subset. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, drinking and smoking.

Table 4 The adjusted associations of chronic conditions between wife and their own husband - Scene 3 (N = 7,844 spouses)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	1.58 (1.41-1.77)	<.0001	1.55 (1.38-1.74)	<.0001	1.48 (1.22-1.80)	<.0001	1.64 (1.09-2.46)	0.0166	0.84 (0.56-1.26)	0.3992	1.35 (0.96-1.90)	0.0892
Hypertension	1.59 (1.42-1.79)	<.0001	1.63 (1.45-1.84)	<.0001	1.46 (1.20-1.77)	0.0001	1.60 (1.08-2.37)	0.0182	0.76 (0.51-1.14)	0.1783	1.11 (0.79-1.56)	0.5353
Diabetes	1.35 (1.13-1.63)	0.0011	1.29 (1.07-1.55)	0.0069	1.57 (1.21-2.03)	0.0007	1.48 (0.90-2.44)	0.1197	0.57 (0.27-1.21)	0.1427	1.02 (0.59-1.77)	0.9357
IHD	1.05 (0.72-1.54)	0.7996	0.96 (0.65-1.42)	0.8379	1.22 (0.71-2.09)	0.4762	6.58 (3.78-11.43)	<.0001	1.68 (0.76-3.69)	0.1994	1.17 (0.42-3.25)	0.7684
CVD	1.10 (0.72-1.67)	0.6596	0.80 (0.52-1.23)	0.3101	0.99 (0.54-1.82)	0.9847	1.36 (0.53-3.48)	0.5263	3.62 (1.86-7.07)	0.0002	1.28 (0.46-3.54)	0.6403
Obesity	1.29 (0.90-1.85)	0.1670	0.87 (0.59-1.29)	0.4888	1.69 (0.99-2.88)	0.0553	1.03 (0.27-3.96)	0.9700	0.58 (0.08-4.31)	0.5953	5.09 (2.92-8.86)	<.0001

Note:

The chronic conditions on the top of table represented the status of wives. The chronic conditions on the left of the table represented the status of their husband. The generalized estimating equations (GEE) model was adjusted for age, health insurance status, education status, drinking and smoking.



Notes: There were 4 participates missing in education status or marriage status in scene 1. There were 4 participates missing in education status or marriage status in scene 2. There was 1 participate missing in education status or marriage status in scene 3.

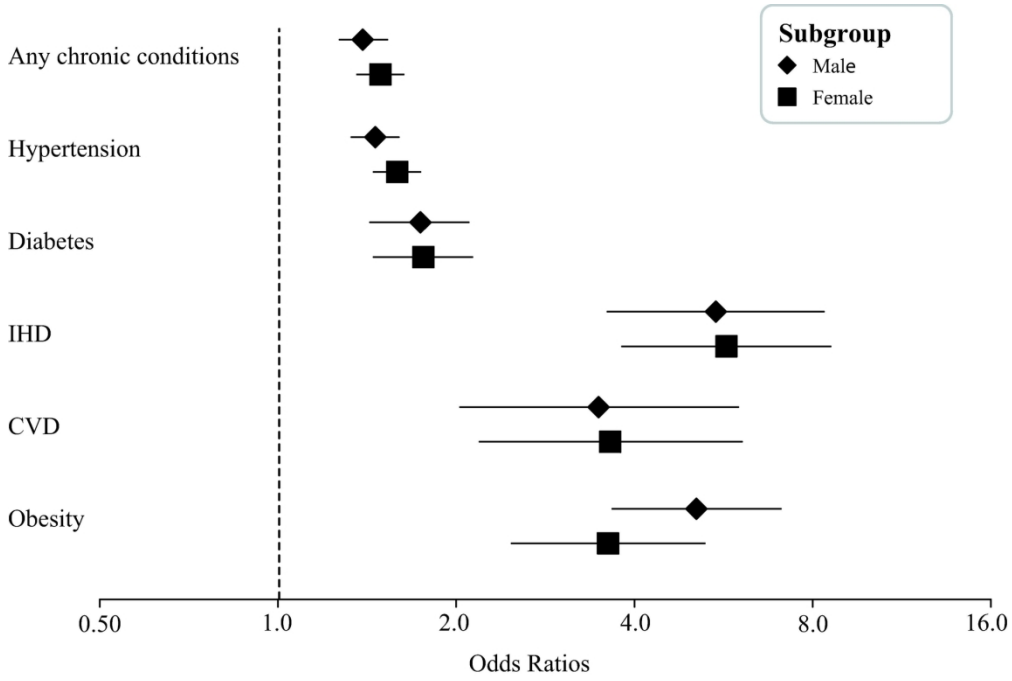


Figure 2 The forest plot of five chronic conditions subgroup analysis categorized by gender. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

171x115mm (300 x 300 DPI)

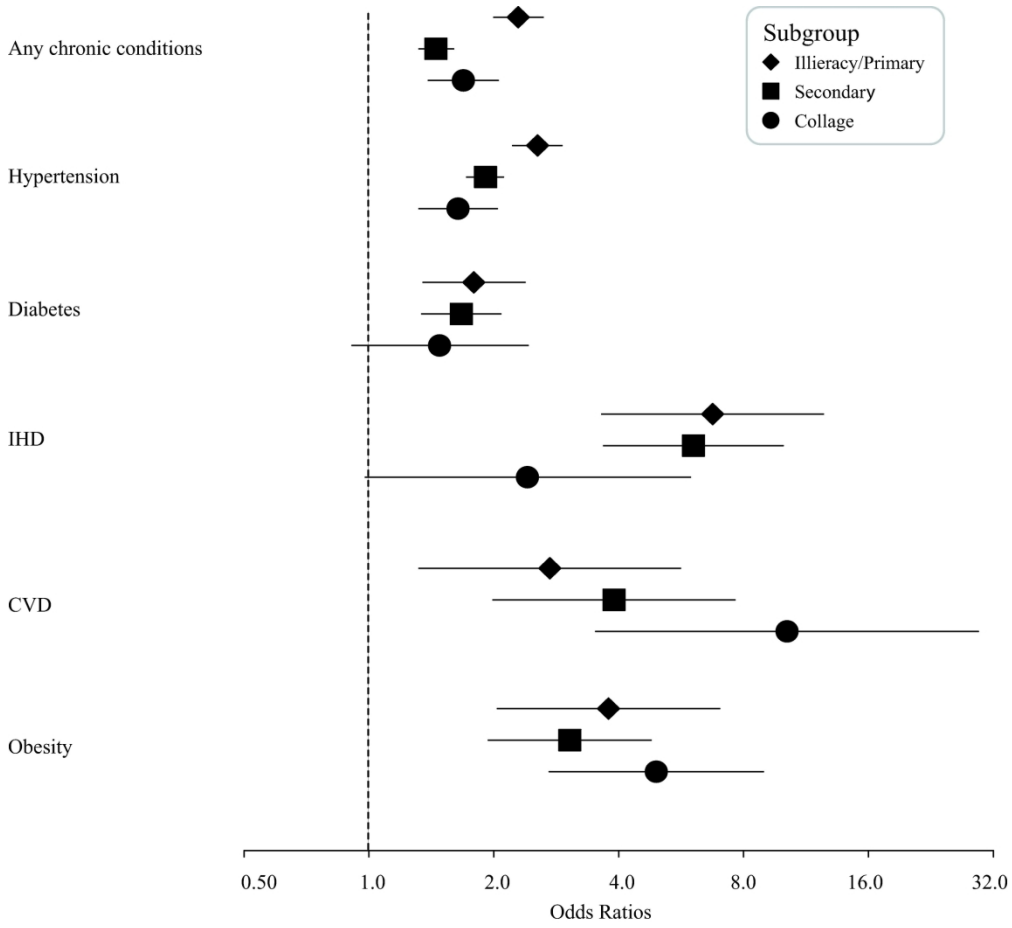


Figure 3 The forest plot of five chronic conditions subgroup analysis categorized by education status. The plot showed the adjusted odds ratios and 95% confidence interval of the association between each given chronic condition of individual with the same condition of household member.

204x187mm (300 x 300 DPI)

Table S1 The crude associations between one's chronic conditions and the disease status of their own household members - Scene 1 (N = 27,010)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	2.26 (2.26-3.81)	<.0001	2.89 (2.69-3.10)	<.0001	1.49 (1.35-1.66)	<.0001	1.34 (1.09-1.65)	0.0050	1.35 (1.09-1.67)	0.0059	1.30 (1.09-1.54)	0.0029
Hypertension	1.96 (1.07-3.57)	0.0282	1.65 (1.52-1.78)	<.0001	1.40 (1.27-1.55)	<.0001	1.51 (1.24-1.83)	<.0001	1.06 (1.32-0.86)	0.5683	1.02 (0.86-1.21)	0.8048
Diabetes	1.36 (1.24-1.48)	<.0001	1.14 (1.05-1.25)	0.0031	1.73 (1.45-2.08)	<.0001	1.23 (0.93-1.63)	0.1493	1.29 (0.96-1.74)	0.0910	1.44 (1.15-1.80)	0.0015
IHD	1.40 (1.19-1.65)	<.0001	1.40 (1.19-1.65)	<.0001	1.19 (0.88-1.59)	0.2568	7.35 (5.04-10.72)	<.0001	2.06 (1.30-3.25)	0.0019	0.89 (0.54-1.47)	0.6472
CVD	1.20 (1.01-1.43)	0.0422	1.08 (0.89-1.29)	0.4362	1.25 (0.95-1.66)	0.1133	1.98 (1.26-3.13)	0.0032	4.45 (2.66-7.44)	<.0001	0.61 (0.31-1.18)	0.1400
Obesity	1.22 (1.06-1.41)	0.0071	0.96 (0.83-1.11)	0.5997	1.32 (1.07-1.64)	0.0104	0.82 (0.50-1.36)	0.4434	0.58 (0.30-1.12)	0.1056	3.43 (2.36-4.98)	<.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members.

Table S2 The adjusted associations of subgroup analyses in all adult household members

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Male												
Any chronic conditions	1.39 (1.27-1.53)	<.0001	1.44 (1.31-1.57)	<.0001	1.22 (1.07-1.41)	0.0044	1.14 (0.85-1.53)	0.3852	1.14 (0.84-1.56)	0.4038	1.10 (0.87-1.39)	0.4386
Hypertension	1.38 (1.26-1.26)	<.0001	1.46 (1.33-1.60)	<.0001	1.21 (1.05-1.39)	0.0070	1.04 (0.78-1.38)	0.8069	0.88 (0.64-1.19)	0.4061	1.03 (0.81-1.30)	0.8218
Diabetes	1.47 (1.28-1.67)	<.0001	1.31 (1.15-1.50)	<.0001	1.74 (1.43-2.10)	<.0001	1.18 (0.78-1.77)	0.4359	1.33 (0.88-2.03)	0.1776	1.51 (1.09-2.09)	0.0123
IHD	1.12 (0.87-1.43)	0.3866	1.12 (0.87-1.45)	0.3700	0.93 (0.63-1.39)	0.7375	5.49 (3.60-8.36)	<.0001	1.45 (0.74-2.86)	0.2764	0.70 (0.32-1.55)	0.3791
CVD	0.93 (0.70-1.24)	0.6254	0.80 (0.59-1.08)	0.1487	0.94 (0.61-1.46)	0.7936	1.64 (0.84-3.22)	0.1484	3.48 (2.03-5.99)	<.0001	0.73 (0.30-1.73)	0.4709
Obesity	1.47 (1.18-1.82)	0.0005	1.31 (1.06-1.61)	0.0115	1.27 (0.93-1.74)	0.1271	1.04 (0.52-2.07)	0.9131	0.87 (0.40-1.93)	0.7368	5.09 (3.67-7.07)	<.0001
Female												
Any chronic conditions	1.49 (1.36-1.63)	<.0001	1.49 (1.36-1.63)	<.0001	1.39 (1.21-1.60)	<.0001	1.31 (1.01-1.71)	0.0453	0.91 (0.68-1.22)	0.5335	1.36 (1.08-1.71)	0.0101
Hypertension	1.49 (1.36-1.62)	<.0001	1.59 (1.45-1.74)	<.0001	1.26 (1.10-1.45)	0.0011	1.32 (1.02-1.71)	0.0365	0.86 (0.64-1.15)	0.3052	1.15 (0.92-1.45)	0.2201

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Diabetes	1.28 (1.12-1,46)	0.0002	1.28 (1.12-1.46)	0.0003	1.76 (1.45-2.13)	<.0001	0.95 (0.65-1.40)	0.8038	0.95 (0.60-1.49)	0.8158	1.32 (0.96-1.81)	0.0902
IHD	1.06 (0.82-1.36)	0.6716	1.01 (0.78-1.31)	0.9455	1.09 (0.75-1.59)	0.6389	5.72 (3.81-8.58)	<.0001	1.47 (0.75-2.87)	0.2645	1.03 (0.52-2.01)	0.9400
CVD	0.97 (0.74-1.26)	0.8189	0.83 (0.63-1.09)	0.1782	1.16 (0.77-1.75)	0.4648	1.43 (0.72-2.82)	0.3023	3.64 (2.19-6.08)	<.0001	0.52 (0.19-1.39)	0.1907
Obesity	1.13 (0.90-1.42)	0.2994	1.00 (0.79-1.27)	0.9974	1.52 (1.11-2.09)	0.0100	0.65 (0.28-1.50)	0.3101	0.27 (0.06-1.11)	0.0699	3.61 (2.48-5.26)	<.0001
Illieracy/Primary												
Any chronic conditions	2.29 (2.00-2.63)	<.0001	1.50 (1.31-1.71)	<.0001	1.16 (0.97-1.38)	0.1064	0.95 (0.68-1.34)	0.7815	0.95 (0.70-1.29)	0.7388	1.19 (0.85-1.67)	0.3038
Hypertension	1.77 (1.55-2.01)	<.0001	2.55 (2.22-2.92)	<.0001	1.12 (0.94-1.33)	0.2053	0.97 (0.70-1.35)	0.8688	0.99 (0.74-1.34)	0.9727	1.00 (0.72-1.38)	0.9855
Diabetes	1.20 (1.00-1.43)	0.0445	1.22 (1.03-1.44)	0.0229	1.79 (1.35-2.38)	<.0001	0.70 (0.40-1.24)	0.2242	0.77 (0.48-1.26)	0.3011	1.18 (0.72-1.93)	0.5080
IHD	1.05 (0.74-1.48)	0.7975	0.97 (0.70-1.36)	0.8720	0.86 (0.48-1.54)	0.6177	6.74 (3.64-12.46)	<.0001	2.03 (1.05-3.92)	0.0360	1.26 (0.48-3.36)	0.6389
CVD	0.94 (0.68-1.29)	0.6994	0.85 (0.62-1.17)	0.3135	0.83 (0.50-1.39)	0.4814	1.86 (0.91-3.80)	0.0883	2.73 (1.32-5.64)	0.0066	1.17 (0.49-2.81)	0.7180

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Obesity	1.20 (0.91-1.58)	0.2047	1.07 (0.81-1.40)	0.6397	1.46 (1.01-2.13)	0.0450	1.02 (0.45-2.32)	0.9649	0.62 (0.25-1.54)	0.3065	3.78 (2.04-7.01)	<.0001
Seconary												
Any chronic conditions	1.45 (1.32-1.60)	<.0001	1.43 (1.29-1.58)	<.0001	1.37 (1.20-1.58)	<.0001	1.36 (1.02-1.83)	0.0349	0.97 (0.69-1.37)	0.8698	0.98 (0.78-1.24)	0.8892
Hypertension	1.34 (1.22-1.48)	<.0001	1.91 (1.72-2.11)	<.0001	1.32 (1.16-1.51)	<.0001	1.37 (1.03-1.81)	0.0287	0.76 (0.53-1.08)	0.1227	1.00 (0.80-1.25)	0.9899
Diabetes	1.19 (1.04-1.36)	0.0090	1.29 (1.13-1.46)	0.0001	1.67 (1.34-2.08)	<.0001	1.28 (0.87-1.90)	0.2140	1.61 (1.02-2.53)	0.0395	1.40 (1.03-1.90)	0.0331
IHD	1.05 (0.82-1.33)	0.7096	1.11 (0.86-1.42)	0.4324	0.95 (0.65-1.39)	0.7949	6.06 (3.68-9.97)	<.0001	0.81 (0.32-2.06)	0.6626	0.51 (0.21-1.20)	0.1231
CVD	0.93 (0.70-1.22)	0.5950	0.83 (0.62-1.12)	0.2354	1.33 (0.90-1.96)	0.1528	0.81 (0.32-2.04)	0.6586	3.90 (1.99-7.63)	<.0001	0.24 (0.06-0.98)	0.0467
Obesity	1.32 (1.06-1.64)	0.0132	1.14 (0.92-1.41)	0.2223	1.28 (0.95-1.71)	0.1041	0.73 (0.34-1.57)	0.4245	0.67 (0.24-1.86)	0.4398	3.05 (1.94-4.79)	<.0001
Collage												
Any chronic conditions	1.69 (1.39-2.05)	<.0001	1.55 (1.25-1.91)	<.0001	1.14 (0.83-1.58)	0.4111	1.05 (0.63-1.75)	0.8497	1.12 (0.56-2.23)	0.7439	1.82 (1.25-2.67)	0.0003

Exposure: chronic condition status of any other household members.	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Hypertension	1.43 (1.19-1.73)	0.0002	1.64 (1.32-2.04)	<.0001	1.17 (0.85-1.61)	0.3432	0.93 (0.56-1.53)	0.7628	0.67 (0.33-1.36)	0.2673	1.62 (1.12-2.33)	0.0103
Diabetes	1.70 (1.33-2.16)	<.0001	1.60 (1.22-2.09)	0.0007	1.48 (0.91-2.42)	0.1169	1.23 (0.63-2.41)	0.5452	1.22 (0.51-2.93)	0.6546	1.69 (1.08-2.65)	0.0220
IHD	1.14 (0.75-1.73)	0.5444	1.02 (0.64-1.63)	0.9371	1.28 (0.69-2.39)	0.4309	2.41 (0.98-5.96)	0.0557	1.68 (0.58-4.87)	0.3376	1.58 (0.67-3.70)	0.2928
CVD	1.20 (0.69-2.09)	0.5079	0.72 (0.37-1.39)	0.3256	0.57 (0.20-1.62)	0.2923	2.32 (0.85-6.28)	0.0988	10.19 (3.52-29-46)	<.0001	0.88 (0.21-3.64)	0.8569
Obesity	2.34 (1.52-3.60)	0.0001	1.51 (0.94-2.42)	0.0848	1.70 (0.78-3.71)	0.1829	0.83 (0.18-3.93)	0.8179	-	-	4.93 (2.72-8.93)	<0.0001

Note:

The chronic conditions on the top of table represented the status of participants. The chronic conditions on the left of the table represented the status of any other household members. The generalized estimating equations (GEE) model was adjusted for age, gender, health insurance status, education status, marriage status, drinking and smoking. The adjusted GEE model was not fit for estimate the association between CVD and obesity in the “Collage” subgroup.

Table S3 The crude associations of chronic conditions between children and their own parents - Scene 2 (N = 5,489 dyads)

Exposure:	Any chronic conditions		Hypertension		Diabetes		Obesity	
chronic condition status of parents	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	5.85(4.83-7.09)	<.0001	6.60(5.25-8.28)	<.0001	6.36(3.98-10.18)	<.0001	2.91(2.01-4.20)	<.0001
Hypertension	4.52(3.77-5.41)	<.0001	7.14(5.73-8.90)	<.0001	3.32(2.24-4.90)	<.0001	1.61(1.13-2.29)	0.0085
Diabetes	2.26(1.78-2.87)	<.0001	1.75(1.27-2.41)	0.0007	11.28(7.65-16.62)	<.0001	1.57(0.93-2.67)	0.0941
Obesity	3.09(2.07-4.60)	<.0001	0.82(0.39-1.73)	0.6037	1.98(0.79-4.94)	0.1449	14.88(9.35-23.68)	<.0001

Note:

The chronic conditions on the top of table represented the status of children. The chronic conditions on the left of the table represented the status of their parents. The analyses of IHD and CVD were not conducted because of low prevalence rate in this subset.

Table S4 The crude associations of chronic conditions between wife and their own husband - Scene 3 (N = 7,844 spouses)

Exposure:	Any chronic conditions		Hypertension		Diabetes		IHD		CVD		Obesity	
chronic condition status of any other household members.	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Any chronic conditions	2.88 (2.61-3.18)	<.0001	2.80 (2.53-3.10)	<.0001	2.35 (1.96-2.82)	<.0001	3.41 (2.32-5.02)	<.0001	1.82 (1.24-2.67)	0.0022	1.65 (1.20-2.26)	0.0020
Hypertension	2.91 (2.63-3.22)	<.0001	2.94 (2.65-3.26)	<.0001	2.31 (1.93-2.78)	<.0001	3.30 (2.27-4.80)	<.0001	1.62 (1.10-2.38)	0.0147	1.39 (1.01-1.93)	0.0453
Diabetes	2.09 (1.78-2.46)	<.0001	1.97 (1.67-2.33)	<.0001	2.12 (1.64-2.75)	<.0001	2.51 (1.55-4.05)	0.0002	0.92 (0.44-1.89)	0.8143	1.20 (0.70-2.06)	0.5082
IHD	2.84 (2.01-4.01)	<.0001	2.54 (1.80-3.59)	<.0001	2.38 (1.44-3.95)	0.0008	18.21 (11.18-29.63)	<.0001	5.01 (2.39-10.53)	<.0001	1.55 (0.57-4.26)	0.3911
CVD	2.91 (2.01-4.19)	<.0001	2.18 (1.51-3.15)	<.0001	2.02 (1.15-3.55)	0.0150	3.68 (1.58-8.53)	0.0025	10.16 (5.51-18.73)	<.0001	1.75 (0.64-4.80)	0.2782
Obesity	1.02 (0.74-1.39)	0.9177	0.73 (0.51-1.04)	0.0822	1.42 (0.84-2.38)	0.1863	0.72 (0.18-2.94)	0.6484	0.39 (0.05-2.83)	0.3542	4.72 (2.7108.22)	<.0001

Note:

The chronic conditions on the top of table represented the status of wives. The chronic conditions on the left of the table represented the status of their husband.

Table S5 The results of full models for the association between chronic conditions of individual with the same condition of household member

	Subsample1		Subsample2		Subsample3	
Factors	OR(95%CI)	P	OR(95%CI)	P	OR(95%CI)	P
Any chronic conditions						
Same condition	3.03(2.81-3.28)	<0.0001	5.13(4.20-6.28)	<0.0001	1.58(1.41-1.77)	<0.0001
Age	1.07(1.07-1.07)	<0.0001	1.08(1.08-1.09)	<0.0001	1.08(1.07-1.08)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.16(1.07-1.26)	0.0002	1.48(1.17-1.88)	0.0010	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.82(0.74-0.91)	0.0001	1.02(0.62-1.68)	0.9319	1.08(0.78-1.49)	0.6577
Education status						
Illieracy/Primary	Ref					
Seconary	1.22(1.11-1.34)	<0.0001	1.54(1.07-2.21)	0.0204	1.91(1.54-2.37)	<0.0001
Collage	1.34(1.23-1.45)	<0.0001	1.44(1.13-1.83)	0.0028	1.74(1.43-2.12)	<0.0001
Smoking	1.00(0.91-1.09)	0.9306	1.19(0.92-1.53)	0.1781	1.01(0.70-1.48)	0.9386
Drinking	0.85(0.78-0.93)	0.0002	0.89(0.70-1.13)	0.3515	1.20(0.85-1.70)	0.3001
Hypertension						
Same condition	3.26(3.02-3.52)	<0.0001	6.29(4.92-8.05)	<0.0001	1.63(1.45-1.84)	<0.0001
Age	1.07(1.07-1.07)	<0.0001	1.12(1.11-1.13)	<0.0001	1.08(1.07-1.08)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.10(1.01-1.20)	0.0247	1.26(0.94-1.70)	0.1247	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.98(0.87-1.11)	0.7680	0.73(0.39-1.37)	0.3310	0.98(0.70-1.37)	0.9004
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	1.32(1.20-1.45)	<0.0001	1.56(1.01-2.41)	0.0435	1.92(1.53-2.40)	<0.0001
Collage	1.39(1.28-1.51)	<0.0001	1.50(1.10-2.03)	0.0093	1.76(1.42-2.17)	<0.0001
Smoking	1.03(0.94-1.13)	0.5309	1.13(0.84-1.53)	0.4109	1.11(0.75-1.65)	0.6052
Drinking	0.77(0.70-0.84)	<0.0001	0.71(0.54-0.94)	0.0166	1.22(0.85-1.75)	0.2834
Diabetes						
Same condition	1.68(1.40-2.01)	<0.0001	11.56(7.88-16.98)	<0.0001	1.57(1.21-2.03)	0.0007
Age	1.05(1.04-1.06)	<0.0001	1.08(1.06-1.10)	<0.0001	1.05(1.05-1.06)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.05(0.91-1.20)	0.5013	1.45(0.88-2.37)	0.1409	-	-
Health insurance status						
Insuranced	Ref		Ref			

No insuranced	0.29(0.06-1.48)	0.1362	0.94(0.30-2.93)	0.9158	0.86(0.46-1.59)	0.6258
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	1.00(0.79-1.27)	0.9867	2.34(1.04-5.27)	0.0410	2.23(1.41-3.53)	0.0006
Collage	1.35(1.17-1.55)	<0.0001	2.66(1.45-4.87)	0.0016	2.15(1.40-3.31)	0.0005
Smoking	0.84(0.73-0.96)	0.0130	1.17(0.73-1.89)	0.5071	0.72(0.41-1.29)	0.2728
Drinking	1.12(0.98-1.29)	0.0943	1.11(0.69-1.79)	0.6780	1.32(0.69-2.53)	0.4069
IHD						
Same condition	5.31(3.56-7.92)	<0.0001	-	-	6.58(3.78-11.43)	<0.0001
Age	1.06(1.05-1.07)	<0.0001	-	-	1.11(1.09-1.12)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	0.85(0.64-1.12)	0.2523	-	-	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.52(0.16-1.69)	0.2753	-	-	1.39(0.41-4.73)	0.5993
Education status						
Illieracy/Primary	Ref					
Seconary	0.60(0.43-0.84)	0.0025	-	-	0.39(0.20-0.78)	0.0072
Collage	0.87(0.70-1.10)	0.2495	-	-	0.88(0.47-1.65)	0.6853
Smoking	1.10(0.83-1.46)	0.5087	-	-	2.16(0.28-16.40)	0.4584
Drinking	1.09(0.81-1.46)	0.5672	-	-	0.42(0.18-0.98)	0.0458
CVD						
Same condition	3.40(1.99-5.80)	<0.0001	-	-	3.62(1.86-7.07)	0.0002
Age	1.08(1.07-1.09)	<0.0001	-	-	1.10(1.08-1.12)	<0.0001
Sex						
Female	Ref		Ref		-	-
Male	1.20(0.94-1.54)	0.1491	-	-	-	-
Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.73(0.38-1.40)	0.3380	-	-	1.23(0.35-4.31)	0.7483
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	1.59(1.13-2.24)	0.0072	-	-	1.25(0.55-2.81)	0.5940
Collage	1.24(0.90-1.72)	0.1899	-	-	1.15(0.51-2.60)	0.7410
Smoking	1.34(0.97-1.84)	0.0781	-	-	1.61(0.21-12.13)	0.6429
Drinking	1.32(0.96-1.80)	0.0867	-	-	2.57(0.34-19.52)	0.3603
Obesity						
Same condition	3.41(2.34-4.96)	<0.0001	13.85(8.54-22.46)	<0.0001	5.09(2.92-8.86)	<0.0001
Age	1.01(1.00-1.02)	0.0462	1.00(0.98-1.02)	0.8932	1.02(1.01-1.04)	0.0015
Sex						
Female	Ref		Ref		-	-
Male	1.08(0.88-1.33)	0.4682	2.04(1.31-3.17)	0.0017	-	-

Health insurance status						
Insuranced	Ref		Ref		Ref	
No insuranced	0.37(0.06-2.09)	0.2588	1.18(0.55-2.53)	0.6670	1.56(0.72-3.41)	0.2630
Education status						
Illieracy/Primary	Ref		Ref		Ref	
Seconary	0.87(0.56-1.35)	0.5298	1.08(0.44-2.64)	0.8624	2.06(0.98-4.32)	0.0558
Collage	1.04(0.81-1.34)	0.7469	1.27(0.82-1.98)	0.2858	2.11(1.06-4.20)	0.0339
Smoking	1.11(0.89-1.39)	0.3468	1.14(0.69-1.89)	0.6041	1.22(0.38-3.86)	0.7376
Drinking	1.02(0.82-1.26)	0.8914	1.47(0.83-2.58)	0.1846	0.89(0.37-2.17)	0.8004

Supplementary S1 The STROBE checklist

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Check	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes. We had indicated that this study is a cross-sectional study in title.	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes. These information was listed in "Abstract".	Page 2
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes. The research about the concordance of chronic conditions among the household members could cause people and health management department to pay attention to the effect of co-residence factor in the prevalence of some chronic diseases.	Page 3
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes. We did effort to test and explore the hypothesis that whether one's chronic conditions are related to the others with chronic conditions living in the same household.	Page 4
Methods				
Study design	4	Present key elements of study design early in the paper	Yes. The data for this study was from the fifth Health Service Survey of Shanghai in 2013 (the extension of China's National Health Service Survey-NHSS), and this is a cross-sectional survey study.	Page5 - Page6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes. This health survey was conducted in Shanghai, China, in 2013. Details could be found in "Data source" section.	Page 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Yes. In our study, we included the households with at least two adults who aged 18 or older.	Page 6
Variables	7	Clearly define all outcomes, exposures,	Yes. We chose five chronic	Page 6

		predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	conditions with high prevalence: hypertension, diabetes, Ischemic heart disease (IHD), cerebrovascular disease (CVD), obesity. Details could be found in "Five chronic conditions" section.	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes. These five chronic conditions were from the self-reported records in the questionnaires, and we chose these diseases according to the disease coding list of the NHSS.	Page5 - Page6
Bias	9	Describe any efforts to address potential sources of bias	Yes. Some socio-demographic characteristics would be included in our analyses as covariates: Age, gender, education status, marriage status, health insurance status, smoking, drinking.	Page 7
Study size	10	Explain how the study size was arrived at	Yes. A total of 10,198 households (27,014 participants) with at least two adults who aged 18 or older were included in our study, and details could be found in figure 1.	Page8 – Page9, Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes. Then the generalized estimating equations (GEE) model with logit link would be used to find out the relationship between one's chronic conditions and the others with chronic conditions living in the same household. And we would estimate these associations in three different household scenes: all household members, dyads of parents and children, and spouses.	Page 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for	Yes. Then the generalized estimating equations (GEE)	Page 8

		confounding	model with logit link would be used in our study with adjusting for age, gender, health insurance status, education status, marriage status, drinking and smoking.	
		(*b*) Describe any methods used to examine subgroups and interactions	Yes. The subgroup analyses would be conducted in all household members scene according to two pre-defined stratification factors: sex (male or female), education (illiteracy/primary, secondary, and college).	Page 8
		(*c*) Explain how missing data were addressed	Yes. We did not conducted any statistical model to deal with the missing data because of low missing data rate. The observation with missing data would be excluded from the final analyses.	Page 8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Yes. The GEE model would be applicable to household data.	Page 8
		(*e*) Describe any sensitivity analyses	Yes. We also conducted crude GEE models to find out the relationship.	Page 8
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes. The details could be found in the first paragraph of "Results" and figure 1.	Page 8 – Page 9, Figure 1
		(b) Give reasons for non-participation at each stage	Yes. The details could be found in the first paragraph of "Results" and figure 1.	Page 8 – Page 9, Figure 1
		(c) Consider use of a flow diagram	Yes. The figure 1 is a flow diagram.	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes. The details could be found in the first paragraph of "Results" and table 1.	Page 9, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Yes. The details could be found in the first paragraph of "Results" and figure 1.	Page 8 – Page 9, Figure 1

Outcome data	15*	Report numbers of outcome events or summary measures	Yes. The details could be found in table 1.	Table 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Yes. The final conclusion was based on the results of the adjusted models. The results of adjusted model were listed in table 2-4, and those of crude model were available in the supplemental tables.	Table 2 – 4
		(*b*) Report category boundaries when continuous variables were categorized		
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes. The results of subgroup analyses were shown in figure 2 and supplemental table S2.	Figure2 & Table S2
Discussion				
Key results	18	Summarise key results with reference to study objectives	Yes. We found that the participants who live with the household members with chronic conditions were associated with 46% higher OR of having one or more chronic condition. For these five chronic conditions, the above relationship was observed in each same chronic condition.	Page 11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes. We discussed four points of limitation in the "Discussion" section.	Page 14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes. The evidence about the effect of co-residence factor in some chronic conditions would suggest that people should pay more attention to their health status, especially those whose household members have chronic conditions. And the mechanisms about these associations should be investigated by further research.	Page 13 – Page 14

Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes. The relationships of chronic conditions among the household members were consistent in three different scenes and subgroups.	Page 13 – Page 14
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	This study was conducted under a grant from the Fourth Round of Shanghai Three-year Action Plan on Public Health Discipline and Talent Program: Evidence-based Public Health and Health Economics(No. 15GWZK0901).	Page 16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Statistical Analysis Plan

Study design and background

From 1993 to 2013, the NHSS has been conducted for five times (every five years) which is a cross-sectional survey. The latest one was conducted in 2013, which was the fifth one. The 5th Health Service Survey of Shanghai was the extension of 5th NHSS. This survey was organized and conducted by the Shanghai Municipal Commission Health and Family Planning. The sampling method and quality assurance measures used in Shanghai survey were consistent with the national sampling approach and principle. The 5th Health Service Survey of Shanghai cover all of the 17 districts in Shanghai, and a three-stage, stratified, random sampling method was adopted. First stage, 100 towns/townships were selected randomly from all these 17 districts. Second stage, one thousand villages/communities were sampled randomly from these selected towns/townships. Third stage, about 12,000 households were identified randomly.

A face-to-face interview approach using structured household questionnaire, which was developed by the National Commission Health and Family Planning of China, was conducted for each household. The questionnaire contained the general information of household, the demographic characteristics of residents, the relationship of household members, self-reported illness and injury, outpatient and inpatient information.

To ensure the quality of this survey, some quality assurance measures were applied during the process of data collection. Logic errors would be checked among the data by survey constitutors. If there were logic errors, the investigators would contact the household members and verify the relevant information. The accuracy of data information were assessed by revisit-approach. The investigators revisited 5% of the sampled households and collected ten key questions to check the consistency of the information recorded. The consistency rates between these two visits was near to 99 %.

Objective

The aim of our study is to estimate the association between an adult's own chronic condition status and the chronic condition status of other household members.

Data management

Those who meet the following conditions will be excluded.

1. Residents less than 18 years old
2. Only one person in a household

Because the NHSS of Shanghai conducted well, there is little data missing in the data set. If one resident missed some important variables, he/she will be excluded from analyses.

Outcomes

We choose five chronic conditions with high prevalence in this survey: hypertension, diabetes, ischemic heart disease (IHD), cerebrovascular disease (CVD), and obesity. The definition of these chronic conditions is based on the question in the questionnaire,

the disease coding list of the NHSS, and Body mass index (BMI).

Hypertension: Hypertension for every resident is indicated based on the question in the questionnaire "Have you ever been told by a doctor that you have hypertension". If one choose "YES", the hypertension status of the participant is "1". If the one choose "NO", the hypertension status of the participant is "0".

Diabetes: Diabetes for every resident is indicated based on the question in the questionnaire "Have you ever been told by a doctor that you have diabetes". If one choose "YES", the diabetes status of the participant is "1". If the one choose "NO", the diabetes status of the participant is "0".

IHD: The questionnaire will record all of the chronic diseases for every resident, and these chronic diseases will been encoded in accordance with the disease coding list of the NHSS. IHD included angina pectoris (061), myocardial infarction (062), and other ischemic heart disease (063). If one choose any of these three codes, the IHD status of the participant is "1". If the one did not choose any of these three codes, the IHD status of the participant is "0".

CVD: This chronic condition will be indicated according to the disease coding list of the NHSS: cerebrovascular disease (067). If one choose this code, the CVD status of the participant is "1". If the one did not choose this code, the CVD status of the participant is "0".

Obesity: Body mass index (BMI) will be calculated for every resident by height and weight. Obesity was indicated by the World Health Organization (WHO) International BMI categories (BMI $\geq$ 30 kg/m^2). If the BMI of the one is equal or over 30 kg/m^2, the obesity status of the participant is "1". If the BMI of the one is lower than 30 kg/m^2, the obesity status of the participant is "0".

Any chronic conditions: If any of these five chronic conditions is "Yes" for a participant, his or her status of "Any chronic conditions" is "Yes", otherwise "Any chronic conditions" is "No"

Covariates

Socio-demographic characteristics added to our models as covariates include age (continuously specified in years), education status (illiteracy/primary, secondary or college), health insurance status (yes or no), marriage status (married, unmarried, divorced or widowed), smoking (yes or no), and drinking (yes or no). Except the analyses of spouse subsample, gender (male or female) and is also included as a covariate.

Subsamples

To make a comprehensive estimation for the association, we conduct the analyses in three subsamples: all adult household members, adult children, and wives.

Subsample 1 all adult household members: We can estimate the general association between an adult's own chronic condition status and the chronic condition status of other household members based on this subsample. The chronic condition status of participant is treated as outcome, and the household situation of chronic condition for each participant is treated as exposure factor. If any other residents (excluding self)

have the given chronic conditions, the exposure for the one is "YES".

Subsample 2 adult children: We only include adult children (age > 18 years old) in this subsample, and those participants are excluded if the disease information of parents were not available. The chronic conditions status of their parents are considered as exposure, and the chronic condition status of adult children is treated as outcome. If any of the one's parents have the given chronic conditions, the exposure for the one is "YES". The results of this subsample might show the effect of genetic factors and common living environment in the relationships that we are interested in.

Subsample 3 wives: we include married women in the analyses. We define the chronic condition of wife as the outcome and the chronic condition of husband as the exposure. The results of this subsample might show the effect of common living environment without genetic ties in the relationships that we are interested in.

Statistical analysis

Descriptive analyses

Descriptive statistics are summarized for the covariates of three subsamples, respectively. Mean (standard deviation, SD) is calculated for continuous variables, and counts (percentages) are calculated for categorical variables.

Generalized Estimating Equations

The generalized estimating equations (GEE) model with logit link will be used to find out the relationship between one's chronic conditions and the others with chronic conditions living in the same household. We consider two-level hierarchical structure of the model (individual within household), and choose the exchangeable working correlation matrix for GEE model. The GEE model is performed using "GENMOD" procedure in SAS software. The analyses model is based on individual's data without considering sampling weight, because there is no relevant information.

The adjusted GEE models will include age, gender, health insurance status, education status, drinking and smoking (gender is excluded in the third subsample). The chronic condition status of participants is included in models as independent variable. And the exposure (status of other members) is included in models as dependent variable. The final conclusion will be based on the results of the adjusted models.

The odds ratio (OR) and 95% confidence interval (CI) are estimated by GEE model to indicate the association between any chronic condition or each given chronic condition of individual with the same condition of household member (e.g., the association between the hypertensive status of a participants and that same condition in his or her other household members). And the association of different chronic condition will also be assessed (e.g., the association between hypertension in a participant and diabetes in other household members).

Sensitivity analysis

We will also estimate the unadjusted odds ratio and 95% confidence interval as sensitivity analysis. And the unadjusted results are required by the STROBE checklist.

Subgroup analysis

We plan to perform two subgroup analysis. One is by gender (male or female) and the

other is by education status (illiteracy/primary, secondary or collage). Illiteracy/primary means the education years were from 0 to 5 years, secondary means the education years were from 6 to 12 years, and collage means the education years of residents were higher than 12 years including undergraduate and graduate degrees. The reason why we perform this two subgroup analysis is this two factors may have a significant influence on living habits which is the cause of chronic conditions.

Other information

All data management and statistical analyses will be performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC). All reported p values are two-sided and p value < 0.05 is regarded as statistically significant. This study will be reported according to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.