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# Sociodemographic and behavioral influences on multimorbidity among adult residents of northeastern China

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## Abstract

**Background:** Multimorbidity is defined as two or more chronic health conditions existing in an individual simultaneously. Multimorbidity has been associated with poor conditions, such as higher health care costs and the poor quality of life. Thus, identifying the risk factors of the multimorbidity is required for multimorbidity prevention.

**Methods:** This study was based on the Comprehensive Demonstration Research Project of Major Chronic Noncommunicable Disease Prevention and Control Technology in Northeast China initiated by China Medical University. The investigation was a cross-sectional study under a multistage stratified cluster random sampling design. Associations between multimorbidity and sociodemographic and behavioral factors in adult residents were investigated using univariate analysis and multivariate logistic regression analysis.

**Results:** A total of 6706 participants were enrolled in this investigation, and the prevalence of multimorbidity was 21.2% among the adult residents of northeastern China. There existed differences of association between age and multimorbidity risks (65–69 years old: OR = 3.53, 95%CI: 2.04–6.12; 70–74 years old: OR = 5.26, 95%CI: 3.02–9.17). Participants who are overweight had significantly high multimorbidity risk (OR = 2.76, 95%CI: 1.50–5.24). Family history of hypertension and family history of diabetes were significantly associated with high multimorbidity risk (family history of hypertension: OR = 2.34, 95%CI: 1.96–2.79; family history of diabetes: OR = 1.77, 95%CI: 1.38–2.26). Compared with the frequency of fatigue (< 1 time/week or 1–2 times/week), that (≥ 3 times/week) was associated with high multimorbidity risk (OR = 1.39, 95%CI: 1.07–1.81). For fresh fruit consumption, compared with eating fruits regularly, eating rarely had a higher risk of multimorbidity (OR = 2.33, 95%CI: 1.90–2.85).

**Conclusions:** Sociodemographic indices (age, BMI, family history of hypertension, and family history of diabetes) and behavioral indices (fatigue status and fresh fruit consumption) increase the risks of multimorbidity. This study provides a necessary route to prevent and control multimorbidity in northeast China.

**Keywords:** Adults, China, Influencing factors, Multimorbidity

## Introduction

Multimorbidity is defined as two or more chronic health conditions existing in an individual simultaneously [1–4]. Multimorbidity increases with aging [5]. Aging is a risk factor of multimorbidity; moreover, the number and proportion of the elderly are increasing sharply in China.

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Thus, China has to face a heavy burden of the multimorbidity in future decades [6, 7].

Multimorbidity has been associated with adverse events, including longer hospitalizations, multiple medical treatments, more complications, psychological distress, higher health care costs, and the poorer quality of life [8–15]. A higher number of chronic conditions in an individual is associated with higher mortality [16–18]. In addition, multimorbidity is associated with a higher risk of unemployment [19], and multimorbidity leads to a substantial economic burden on health care systems [20–22]. Therefore, identifying the risk factors for multimorbidity to further address the major public health problems.

To date, the prevalence and pattern of multimorbidity has been investigated worldwide. The prevalence of multimorbidity are reported as following: 28% in Americans [23], 37.1% in Australia [24], 58.2% in women who are more than 50 years old in Brazil [25], and 6.4–76.5% in the population aged 60 years or more in China [26]. The difference of multimorbidity prevalence may arise from population, data sources, and eating habits from different areas. The major patterns of multimorbidity are identified as cardiovascular and metabolic diseases, mental health problems, and musculoskeletal disorders in the elderly who lived in Europe, the United States (U.S.), and Australia [27]. In contrast, cardiopulmonary-mental-degenerative disorder and cerebrovascular-metabolic disorder are the patterns identified in China [28]. Indeed, different methods, population, and chronic diseases have been used in defining multimorbidity pattern, affording that there exists no consensus on the determination and classification of multimorbidity pattern.

The prevention and control of chronic disease are necessary for multimorbidity management, underscoring the identification of risk factors of the multimorbidity. The risk factors for multimorbidity have been identified in studies, including age, female, and low socioeconomic status [29–31]. Moreover, influencing factors of multimorbidity, such as racial and ethnic, remain controversial [32, 33]. Thus, more studies are needed to investigate risk factors for multimorbidity. In this paper, we investigated the prevalence of multimorbidity and further evaluated the sociodemographic and behavioral influences on multimorbidity among adult residents to identify the risk factors for multimorbidity in Changchun, China.

## Materials and methods

### Ethical statement

The study was approved by the Ethics Committee of China Medical University. The study protocol was performed in accordance with the principles outlined in the

Declaration of Helsinki, and informed consent was collected from each of participants.

### Study population

The study was affiliated to the Comprehensive Demonstration Research Project of Major Chronic Noncommunicable Disease Prevention and Control Technology in Northeast China initiated by China Medical University. The investigation, which was conducted from January 1, 2019 to November 31, 2019, was a cross-sectional study under a multistage stratified cluster random sampling design. The data were collected from residents of 10 districts in Changchun city, Jilin Province. The adult residents were enrolled according to following inclusion criteria: (1) over the age of 35 years; (2) with registered permanent residence (a record officially identifying area residents); (3) living in Changchun for more than 6 months; (4) with consciousness and no communication barriers; (5) good compliance. The exclusion criteria satisfied the followings: (1) incomplete information; (2) data with outliers. (Supplemental Fig. 1).

### Questionnaire and health examination

The questionnaire was designed by the China Medical University and the School of Public Health, Jilin University. Direct face-to-face interview survey was performed by uniformly trained investigators. Questionnaires and data of anthropometric measurements were collected from each participant. Demographic information (sex, age, ethnicity, marital status, occupation, annual income, and level of education), health behaviors (smoking, drinking, diet, sleep status, and physical activity), and history of chronic diseases (hypertension, diabetes, coronary heart disease, and stroke), were collected from the questionnaires. In addition, the information of anthropometric measurements (height, weight, blood pressure, fasting blood glucose, and blood lipids) were obtained from health examination. Every physical measurement was checked by two medical staffs together. Blood samples were collected and transported to a central laboratory via a cold chain transport system.

### Statistical analysis

Constituent ratio was used to represent the composition of prevalence of chronic diseases for classified participants according to sociodemographic and behavioral characteristics. *Chi-square* ( $\chi^2$ ) test was used to identify the relationship of multimorbidity with sociodemographic and behavioral characteristics. Multivariate logistic regression was performed to analyze odds ratios (OR) for multimorbidity. The predictive models were built on the basis of risk factors and visualized using nomograms,

**Table 1** Prevalence of number of chronic diseases by sociodemographic and behavioral characteristics of the study population

| Variables                                | Total (n) | 0disease |      | 1disease |      | 2diseases |      | ≥3diseases |      | $\chi^2$ | P       |
|--|-----------|----------|------|----------|------|-----------|------|------------|------|----------|---------|
|  |           | n        | %    | n        | %    | n         | %    | n          | %    |          |         |
| Sex                                      |           |          |      |          |      |           |      |            |      |          |         |
| Male                                     | 2677      | 1082     | 40.4 | 1045     | 39.0 | 450       | 16.8 | 100        | 3.7  | 3.481    | 0.323   |
| Female                                   | 4029      | 1551     | 38.5 | 1604     | 39.8 | 699       | 17.3 | 175        | 4.3  |          |         |
| Age (year)                               |           |          |      |          |      |           |      |            |      |          |         |
| ≤ 64                                     | 191       | 114      | 59.7 | 62       | 32.5 | 12        | 6.3  | 3          | 1.6  | 94.721   | <0.001* |
| 65–69                                    | 3929      | 1643     | 41.8 | 1519     | 38.7 | 637       | 16.2 | 130        | 3.3  |          |         |
| 70–74                                    | 2586      | 876      | 33.9 | 1068     | 41.3 | 500       | 19.3 | 142        | 5.5  |          |         |
| Ethnicity                                |           |          |      |          |      |           |      |            |      |          |         |
| Han                                      | 6517      | 2558     | 39.3 | 2576     | 39.5 | 1121      | 17.2 | 262        | 4.0  | 4.316    | 0.229   |
| Non-Han                                  | 189       | 75       | 39.7 | 73       | 38.6 | 28        | 14.8 | 13         | 6.9  |          |         |
| BMI                                      |           |          |      |          |      |           |      |            |      |          |         |
| Underweight                              | 102       | 55       | 53.9 | 36       | 35.3 | 9         | 8.8  | 2          | 2.0  | 163.603  | <0.001* |
| Normal                                   | 2568      | 1230     | 47.9 | 911      | 35.5 | 351       | 13.7 | 76         | 3.0  |          |         |
| Overweight                               | 3961      | 1316     | 33.2 | 1674     | 42.3 | 775       | 19.6 | 196        | 4.9  |          |         |
| Obese                                    | 75        | 32       | 42.7 | 28       | 37.3 | 14        | 18.7 | 1          | 1.3  |          |         |
| Marital status                           |           |          |      |          |      |           |      |            |      |          |         |
| Married/Cohabitation                     | 35        | 18       | 51.4 | 14       | 40.0 | 3         | 8.6  | 0          | 0.0  | 14.601   | 0.024*  |
| Unmarried                                | 5923      | 2357     | 39.8 | 2325     | 39.3 | 1007      | 17   | 234        | 4.0  |          |         |
| Divorced/ Separated                      | 748       | 258      | 34.5 | 310      | 41.4 | 139       | 18.6 | 41         | 5.5  |          |         |
| Family history of hypertension           |           |          |      |          |      |           |      |            |      |          |         |
| No                                       | 5940      | 2450     | 41.2 | 2353     | 39.6 | 949       | 16   | 188        | 3.2  | 203.931  | <0.001* |
| Yes                                      | 766       | 183      | 23.9 | 296      | 38.6 | 200       | 26.1 | 87         | 11.4 |          |         |
| Family history of diabetes               |           |          |      |          |      |           |      |            |      |          |         |
| No                                       | 6064      | 2427     | 40   | 2418     | 39.9 | 1004      | 16.6 | 215        | 3.5  | 109.425  | <0.001* |
| Yes                                      | 349       | 83       | 23.8 | 133      | 38.1 | 89        | 25.5 | 44         | 12.6 |          |         |
| Educational level                        |           |          |      |          |      |           |      |            |      |          |         |
| Primary school or below                  | 162       | 52       | 32.1 | 69       | 42.6 | 36        | 22.2 | 5          | 3.1  | 20.846   | 0.013*  |
| Junior middle school                     | 861       | 300      | 34.8 | 378      | 43.9 | 151       | 17.5 | 32         | 3.7  |          |         |
| Senior middle school                     | 2280      | 879      | 38.6 | 915      | 40.1 | 388       | 17   | 98         | 4.3  |          |         |
| Undergraduate or above                   | 3403      | 1402     | 41.2 | 1287     | 37.8 | 574       | 16.9 | 140        | 4.1  |          |         |
| Occupation                               |           |          |      |          |      |           |      |            |      |          |         |
| Agriculture                              | 321       | 102      | 31.8 | 140      | 43.6 | 62        | 19.3 | 17         | 5.3  | 61.841   | <0.001* |
| Industry                                 | 512       | 212      | 41.4 | 198      | 38.7 | 79        | 15.4 | 23         | 4.5  |          |         |
| Individual business and service industry | 521       | 231      | 44.3 | 192      | 36.9 | 86        | 16.5 | 12         | 2.3  |          |         |
| Agency and business unit                 | 592       | 291      | 49.2 | 192      | 32.4 | 88        | 14.9 | 21         | 3.5  |          |         |
| Retirement                               | 3638      | 1410     | 38.8 | 1432     | 39.4 | 633       | 17.4 | 163        | 4.5  |          |         |
| Unemployment                             | 664       | 231      | 34.8 | 302      | 45.5 | 108       | 16.3 | 23         | 3.5  |          |         |
| Other                                    | 458       | 156      | 34.1 | 193      | 42.1 | 93        | 20.3 | 16         | 3.5  |          |         |
| Annual income (¥)                        |           |          |      |          |      |           |      |            |      |          |         |
| < 10,000                                 | 563       | 196      | 34.8 | 240      | 42.6 | 91        | 16.2 | 36         | 6.4  | 89.176   | <0.001* |
| 10,000~30,000                            | 2817      | 960      | 34.1 | 1237     | 43.9 | 508       | 18   | 112        | 4.0  |          |         |
| 30,000~50,000                            | 2765      | 1213     | 43.9 | 987      | 35.7 | 464       | 16.8 | 101        | 3.7  |          |         |
| ≥ ~50,000                                | 561       | 264      | 47.1 | 185      | 33.0 | 86        | 15.3 | 26         | 4.6  |          |         |
| Physical exercise                        |           |          |      |          |      |           |      |            |      |          |         |
| Every day                                | 4912      | 1893     | 38.5 | 2002     | 40.8 | 827       | 16.8 | 190        | 3.9  | 30.286   | 0.003*  |
| 3-4 days/week                            | 220       | 109      | 49.5 | 69       | 31.4 | 35        | 15.9 | 7          | 3.2  |          |         |
| 2-3 days/week                            | 200       | 96       | 48   | 62       | 31.0 | 30        | 15   | 12         | 6.0  |          |         |

**Table 1** (continued)

| Variables                      | Total (n) | 0disease |      | 1disease |      | 2diseases |      | ≥3diseases |     | $\chi^2$ | P       |
|--------------------------------|-----------|----------|------|----------|------|-----------|------|------------|-----|----------|---------|
|                                |           | n        | %    | n        | %    | n         | %    | n          | %   |          |         |
| 1-2 days/month                 | 39        | 16       | 41   | 15       | 38.5 | 5         | 12.8 | 3          | 7.7 |          |         |
| Never                          | 1335      | 519      | 38.9 | 501      | 37.5 | 252       | 18.9 | 63         | 4.7 |          |         |
| Sleep status                   |           |          |      |          |      |           |      |            |     |          |         |
| Worse                          | 76        | 20       | 26.3 | 34       | 44.7 | 16        | 21.1 | 6          | 7.9 | 28.86    | 0.004*  |
| Poor                           | 622       | 216      | 34.7 | 237      | 38.1 | 131       | 21.1 | 38         | 6.1 |          |         |
| Average                        | 2015      | 796      | 39.5 | 787      | 39.1 | 343       | 17   | 89         | 4.4 |          |         |
| Good                           | 3642      | 1453     | 39.9 | 1457     | 40.0 | 600       | 16.5 | 132        | 3.6 |          |         |
| Excellent                      | 351       | 148      | 42.2 | 134      | 38.2 | 59        | 16.8 | 10         | 2.8 |          |         |
| Fatigueness status (time/week) |           |          |      |          |      |           |      |            |     |          |         |
| <1                             | 5304      | 2096     | 39.5 | 2114     | 39.9 | 887       | 16.7 | 207        | 3.9 | 22.967   | 0.001*  |
| 1–2                            | 1061      | 418      | 39.4 | 420      | 39.6 | 178       | 16.8 | 45         | 4.2 |          |         |
| ≥ 3                            | 341       | 119      | 34.9 | 115      | 33.7 | 84        | 24.6 | 23         | 6.7 |          |         |
| Stay up late                   |           |          |      |          |      |           |      |            |     |          |         |
| Often                          | 214       | 96       | 44.9 | 70       | 32.7 | 40        | 18.7 | 8          | 3.7 | 44.007   | <0.001* |
| Sometimes                      | 479       | 229      | 47.8 | 162      | 33.8 | 71        | 14.8 | 17         | 3.5 |          |         |
| Rarely                         | 1243      | 548      | 44.1 | 447      | 36.0 | 194       | 15.6 | 54         | 4.3 |          |         |
| Never                          | 4770      | 1760     | 36.9 | 1970     | 41.3 | 844       | 17.7 | 196        | 4.1 |          |         |
| Smoking status                 |           |          |      |          |      |           |      |            |     |          |         |
| Smoker                         | 945       | 366      | 38.7 | 377      | 39.9 | 161       | 17   | 41         | 4.3 | 0.28     | 0.964   |
| Non-smoker                     | 5761      | 2267     | 39.4 | 2272     | 39.4 | 988       | 17.1 | 234        | 4.1 |          |         |
| Status of alcohol drinking     |           |          |      |          |      |           |      |            |     |          |         |
| Drinker                        | 815       | 325      | 39.9 | 329      | 40.4 | 132       | 16.2 | 29         | 3.6 | 1.407    | 0.704   |
| Non-drinker                    | 5891      | 2308     | 39.2 | 2320     | 39.4 | 1017      | 17.3 | 246        | 4.2 |          |         |
| Salt taste                     |           |          |      |          |      |           |      |            |     |          |         |
| Salty                          | 427       | 181      | 42.4 | 134      | 31.4 | 85        | 19.9 | 27         | 6.3 | 96.487   | <0.001* |
| Insipid                        | 1411      | 480      | 34   | 548      | 38.8 | 275       | 19.5 | 108        | 7.7 |          |         |
| Appropriate                    | 4868      | 1972     | 40.5 | 1967     | 40.4 | 789       | 16.2 | 140        | 2.9 |          |         |
| Edible oil taste               |           |          |      |          |      |           |      |            |     |          |         |
| Greasy                         | 278       | 120      | 43.2 | 89       | 32.0 | 56        | 20.1 | 13         | 4.7 | 77.108   | <0.001* |
| Thin                           | 1330      | 488      | 36.7 | 486      | 36.5 | 251       | 18.9 | 105        | 7.9 |          |         |
| Appropriate                    | 5098      | 2025     | 39.7 | 2074     | 40.7 | 842       | 16.5 | 157        | 3.1 |          |         |
| Carbonated drinks              |           |          |      |          |      |           |      |            |     |          |         |
| Yes                            | 111       | 60       | 54.1 | 39       | 35.1 | 10        | 9    | 2          | 1.8 | 12.637   | 0.005*  |
| No                             | 6595      | 2573     | 39   | 2610     | 39.6 | 1139      | 17.3 | 273        | 4.1 |          |         |
| Fresh fruit consumption        |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                   | 4777      | 2002     | 41.9 | 1850     | 38.7 | 732       | 15.3 | 193        | 4.0 | 123.52   | <0.001* |
| Sometimes                      | 1352      | 505      | 37.4 | 550      | 40.7 | 245       | 18.1 | 52         | 3.8 |          |         |
| Rarely/Never                   | 577       | 126      | 21.8 | 249      | 43.2 | 172       | 29.8 | 30         | 5.2 |          |         |
| Meat consumption (red meet)    |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                   | 1829      | 741      | 40.5 | 729      | 39.9 | 287       | 15.7 | 72         | 3.9 | 14.157   | 0.028*  |
| Sometimes                      | 3593      | 1441     | 40.1 | 1384     | 38.5 | 621       | 17.3 | 147        | 4.1 |          |         |
| Rarely/Never                   | 1284      | 451      | 35.1 | 536      | 41.7 | 241       | 18.8 | 56         | 4.4 |          |         |
| Meat consumption (poultry)     |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                   | 1375      | 570      | 41.5 | 548      | 39.9 | 209       | 15.2 | 48         | 3.5 | 24.06    | 0.001*  |
| Sometimes                      | 3810      | 1535     | 40.4 | 1467     | 38.6 | 644       | 16.9 | 155        | 4.1 |          |         |
| Rarely/Never                   | 1530      | 528      | 34.5 | 634      | 41.4 | 296       | 19.3 | 72         | 4.7 |          |         |
| Consumption of fish            |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                   | 747       | 322      | 43.1 | 281      | 37.6 | 113       | 15.1 | 31         | 4.1 | 23.499   | 0.001*  |

**Table 1** (continued)

| Variables                     | Total (n) | 0disease |      | 1disease |      | 2diseases |      | ≥3diseases |     | $\chi^2$ | P       |
|-------------------------------|-----------|----------|------|----------|------|-----------|------|------------|-----|----------|---------|
|                               |           | n        | %    | n        | %    | n         | %    | n          | %   |          |         |
| Sometimes                     | 3881      | 1580     | 40.7 | 1500     | 38.6 | 648       | 16.7 | 153        | 3.9 |          |         |
| Rarely/Never                  | 2078      | 731      | 35.2 | 868      | 41.8 | 388       | 18.7 | 91         | 4.4 |          |         |
| Consumption of eggs and beans |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                  | 3837      | 1569     | 40.9 | 1499     | 39.1 | 609       | 15.9 | 160        | 4.2 | 26.452   | <0.001* |
| Sometimes                     | 2298      | 853      | 37.1 | 927      | 40.3 | 440       | 19.1 | 78         | 3.4 |          |         |
| Rarely/Never                  | 571       | 211      | 37   | 223      | 39.1 | 100       | 17.5 | 37         | 6.5 |          |         |
| Consumption of milk           |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                  | 2974      | 1205     | 40.5 | 1148     | 38.6 | 483       | 16.2 | 138        | 4.6 | 12.477   | 0.052   |
| Sometimes                     | 2265      | 888      | 39.2 | 891      | 39.3 | 407       | 18   | 79         | 3.5 |          |         |
| Rarely/Never                  | 1467      | 540      | 36.8 | 610      | 41.6 | 259       | 17.7 | 58         | 4.0 |          |         |
| Consumption of rice           |           |          |      |          |      |           |      |            |     |          |         |
| Often/Always                  | 5394      | 2144     | 39.7 | 2126     | 39.4 | 906       | 16.8 | 218        | 4.0 | 10.382   | 0.109   |
| Sometimes                     | 1060      | 411      | 38.8 | 417      | 39.3 | 186       | 17.5 | 46         | 4.3 |          |         |
| Rarely/Never                  | 252       | 78       | 31   | 106      | 42.1 | 57        | 22.6 | 11         | 4.4 |          |         |

\* $P < 0.05$ 

and the performance of our models was evaluated using the Harrell's concordance index (c-index). SPSS version 24.0 and R version 4.1.0 were used for statistical analysis, and  $P$ -values  $< 0.05$  was considered statistically significant.

## Results

A total of 6706 participants were enrolled in this investigation. The mean age of the participants was 68.79 years old, and the prevalence of multimorbidity was 21.2%. The participants were divided into four groups according to the number of chronic disease (1 disease, 2 diseases, and  $\geq 3$  diseases), and corresponding data of prevalence are showed in Table 1. Significant differences of prevalence classified by number of chronic diseases existed in age, BMI, marital status, family history of hypertension, family history of diabetes, educational level, occupation, annual income, physical exercise, sleep status, fatigue status, stay up late, salt taste, edible oil taste, carbonated drinks, fresh fruit consumption, meat consumption (red meat and poultry), consumption of fish, and consumption of eggs and beans ( $P < 0.05$ ).

We used univariate analysis to investigate the influencing factors of multimorbidity on the basis of 26 independent variables listed in the questionnaire, finding that multimorbidity was associated with age, BMI, marital status, family history of hypertension, family history of diabetes, sleep status, fatigue status, salt taste, edible oil taste, carbonated drinks, fresh fruit consumption, meat consumption (poultry), consumption of fish, and consumption of eggs and beans ( $P < 0.05$ ) (Table 2).

The prevalence of multimorbidity increased with aging ( $P < 0.001$ ). The prevalence of multimorbidity in participants with underweight, normal weight, overweight, or obese was 10.8, 30.0, 24.5, and 20.0%, correspondingly ( $P < 0.001$ ). There were the significant differences of prevalence in married/cohabitation, unmarried, and divorced/separated (8.6, 21.0, and 24.1%, respectively) ( $P = 0.027$ ). The prevalence of multimorbidity in participants with family history of hypertension/diabetes was significantly higher than that in participants without the respective/corresponding one ( $P < 0.001$ ). The prevalence of multimorbidity increased with the deteriorating of sleep status ( $P < 0.001$ ). The prevalence of multimorbidity increased with the increasing frequency of fatigue ( $P < 0.001$ ). For salt consumption and edible oil consumption, the prevalence of multimorbidity of appropriate consumption was significantly lower than that of excessive consumption or low consumption ( $P < 0.001$ ). There also existed significantly differences in the prevalence among current-smokers (45.1%), ex-smokers (46.5%), and non-smokers (35.3%) ( $P < 0.001$ ). For the consumption of fresh fruit, poultry meat, eggs and beans, and fish, the prevalence of multimorbidity increased with the decreasing frequency of consumption from group (often/always) to group (rarely/never) (all  $P < 0.05$ ) (Table 2).

We further used a multivariate logistic regression analysis, constructing a prediction model to validate multimorbidity-influencing factors. Data of the multiple logistic regression analysis, shown in Fig. 1, are visualized in the form of a nomogram to provide effective and reliable guides (Fig. 2). We identified that the increasing

**Table 2** Univariate factor analysis of multimorbidity

| Variables                                | No Multimorbidity |      | Multimorbidity |      | $\chi^2$ | P        |       |       |
|--|-------------------|------|----------------|------|----------|----------|-------|-------|
|  | n                 | %    | n              | %    |          |          |       |       |
| Total                                    | 5282              | 78.8 | 1424           | 21.2 |          |          |       |       |
| Sex                                      |                   |      |                |      |          |          |       |       |
| Male                                     | 2127              | 79.5 | 550            | 20.5 | 1.266    | 0.261    |       |       |
| Female                                   | 3155              | 78.3 | 874            | 21.7 |          |          |       |       |
| Age (year)                               |                   |      |                |      |          |          |       |       |
| ≤ 64                                     | 176               | 92.1 | 15             | 7.9  | 47.284   | < 0.001* |       |       |
| 65–69                                    | 3162              | 80.5 | 767            | 19.5 |          |          |       |       |
| 70–74                                    | 1944              | 75.2 | 642            | 24.8 |          |          |       |       |
| Ethnicity                                |                   |      |                |      |          |          |       |       |
| Han                                      | 5134              | 78.8 | 1383           | 21.2 | 0.024    | 0.876    |       |       |
| Non-Han                                  | 148               | 78.3 | 41             | 21.7 |          |          |       |       |
| BMI                                      |                   |      |                |      |          |          |       |       |
| Underweight                              | 91                | 89.2 | 11             | 10.8 | 64.783   | < 0.001* |       |       |
| Normal                                   | 2141              | 40.5 | 427            | 30.0 |          |          |       |       |
| Overweight                               | 2990              | 75.5 | 971            | 24.5 |          |          |       |       |
| Obese                                    | 60                | 80.0 | 15             | 20.0 |          |          |       |       |
| Marital status                           |                   |      |                |      |          |          |       |       |
| Married/Cohabitation                     | 32                | 91.4 | 3              | 8.6  | 7.219    | 0.027*   |       |       |
| Unmarried                                | 4682              | 79.0 | 1241           | 21.0 |          |          |       |       |
| Divorced/ Separated                      | 568               | 75.9 | 180            | 24.1 |          |          |       |       |
| Family history of hypertension           |                   |      |                |      |          |          |       |       |
| No                                       | 4803              | 80.9 | 1137           | 19.1 | 136.24   | < 0.001* |       |       |
| Yes                                      | 479               | 62.5 | 287            | 37.5 |          |          |       |       |
| Family history of diabetes               |                   |      |                |      |          |          |       |       |
| No                                       | 4845              | 79.9 | 1219           | 20.1 | 66.016   | < 0.001* |       |       |
| Yes                                      | 216               | 61.9 | 133            | 38.1 |          |          |       |       |
| Educational level                        |                   |      |                |      |          |          |       |       |
| Primary school or below                  | 121               | 74.7 | 41             | 25.3 | 1.747    | 0.627    |       |       |
| Junior middle school                     | 678               | 78.7 | 183            | 21.3 |          |          |       |       |
| Senior middle school                     | 1794              | 78.7 | 486            | 21.3 |          |          |       |       |
| Undergraduate or above                   | 2689              | 79.0 | 714            | 21.0 |          |          |       |       |
| Occupation                               |                   |      |                |      |          |          |       |       |
| Agriculture                              | 242               | 75.4 | 79             | 24.6 | 10.973   | 0.089    |       |       |
| Industry                                 | 410               | 80.1 | 102            | 19.9 |          |          |       |       |
| Individual business and service industry | 423               | 81.2 | 98             | 18.8 |          |          |       |       |
| Agency and business unit                 | 483               | 81.6 | 109            | 18.4 |          |          |       |       |
| Retirement                               | 2842              | 78.1 | 796            | 21.9 |          |          |       |       |
| Unemployment                             | 533               | 80.3 | 131            | 19.7 |          |          |       |       |
| Other                                    | 349               | 76.2 | 109            | 23.8 |          |          |       |       |
| Annual income (¥)                        |                   |      |                |      |          |          |       |       |
| < 10,000                                 | 436               | 77.4 | 127            | 22.6 |          |          | 3.201 | 0.362 |
| 10,000~30,000                            | 2197              | 78.0 | 620            | 22.0 |          |          |       |       |
| 30,000~50,000                            | 2200              | 79.6 | 565            | 20.4 |          |          |       |       |
| ≥ ~50,000                                | 449               | 80.0 | 112            | 20.0 |          |          |       |       |
| Physical exercise                        |                   |      |                |      |          |          |       |       |
| Every day                                | 3895              | 79.3 | 1017           | 20.7 | 5.898    | 0.207    |       |       |
| 3-4 days/week                            | 178               | 80.9 | 42             | 19.1 |          |          |       |       |

**Table 2** (continued)

| Variables                      | No Multimorbidity |      | Multimorbidity |      | $\chi^2$ | P       |
|--------------------------------|-------------------|------|----------------|------|----------|---------|
|                                | n                 | %    | n              | %    |          |         |
| 2-3 days/week                  | 158               | 79.0 | 42             | 21.0 |          |         |
| 1-2 days/month                 | 31                | 79.5 | 8              | 20.5 |          |         |
| Never                          | 1020              | 76.4 | 315            | 23.6 |          |         |
| Sleep status                   |                   |      |                |      |          |         |
| Worse                          | 54                | 71.1 | 22             | 28.9 | 19.187   | 0.001*  |
| Poor                           | 453               | 72.8 | 169            | 27.2 |          |         |
| Average                        | 1583              | 78.6 | 432            | 21.4 |          |         |
| Good                           | 2910              | 79.9 | 732            | 20.1 |          |         |
| Excellent                      | 282               | 80.3 | 69             | 19.7 |          |         |
| Fatigueness status (time/week) |                   |      |                |      |          |         |
| <1                             | 4210              | 79.4 | 1094           | 20.6 | 22.183   | <0.001* |
| 1–2                            | 838               | 79.0 | 223            | 21.0 |          |         |
| ≥ 3                            | 234               | 68.6 | 107            | 31.4 |          |         |
| Stay up late                   |                   |      |                |      |          |         |
| Often                          | 166               | 77.6 | 48             | 22.4 | 4.675    | 0.197   |
| Sometimes                      | 391               | 81.6 | 88             | 18.4 |          |         |
| Rarely                         | 995               | 80.0 | 248            | 20.0 |          |         |
| Never                          | 3730              | 78.2 | 1040           | 21.8 |          |         |
| Smoking status                 |                   |      |                |      |          |         |
| Smoker                         | 743               | 78.6 | 202            | 21.4 | 0.013    | 0.909   |
| Non-smoker                     | 4539              | 85.9 | 1222           | 85.8 |          |         |
| Status of alcohol drinking     |                   |      |                | 0.0  |          |         |
| Drinker                        | 654               | 80.2 | 161            | 19.8 | 1.215    | 0.27    |
| Non-drinker                    | 4628              | 78.6 | 1263           | 21.4 |          |         |
| Salt taste                     |                   |      |                |      |          |         |
| Salty                          | 315               | 73.8 | 112            | 26.2 | 49.292   | <0.001* |
| Insipid                        | 1028              | 72.9 | 383            | 27.1 |          |         |
| Appropriate                    | 3939              | 80.9 | 929            | 19.1 |          |         |
| Edible oil taste               |                   |      |                |      |          |         |
| Greasy                         | 209               | 75.2 | 69             | 24.8 | 34.66    | <0.001* |
| Thin                           | 974               | 73.2 | 356            | 26.8 |          |         |
| Appropriate                    | 4099              | 80.4 | 999            | 19.6 |          |         |
| Carbonated drinks              |                   |      |                |      |          |         |
| Yes                            | 99                | 89.2 | 12             | 10.8 | 7.332    | 0.007*  |
| No                             | 5183              | 78.6 | 1412           | 21.4 |          |         |
| Fresh fruit consumption        |                   |      |                |      |          |         |
| Often/Always                   | 3852              | 80.6 | 925            | 19.4 | 75.884   | <0.001* |
| Sometimes                      | 1055              | 78.0 | 297            | 22.0 |          |         |
| Rarely/Never                   | 375               | 65.0 | 202            | 35.0 |          |         |
| Meat consumption (red meat)    |                   |      |                |      |          |         |
| Often/Always                   | 1470              | 80.4 | 359            | 19.6 | 5.625    | 0.06    |
| Sometimes                      | 2825              | 78.6 | 768            | 21.4 |          |         |
| Rarely/Never                   | 987               | 76.9 | 297            | 23.1 |          |         |
| Meat consumption (poultry)     |                   |      |                |      |          |         |
| Often/Always                   | 1118              | 81.3 | 257            | 18.7 | 12.686   | 0.002*  |
| Sometimes                      | 3002              | 79.0 | 799            | 21.0 |          |         |
| Rarely/Never                   | 1162              | 75.9 | 368            | 24.1 |          |         |

**Table 2** (continued)

| Variables                     | No Multimorbidity |      | Multimorbidity |      | $\chi^2$ | P      |
|-------------------------------|-------------------|------|----------------|------|----------|--------|
|                               | n                 | %    | n              | %    |          |        |
| Consumption of fish           |                   |      |                |      |          |        |
| Often/Always                  | 603               | 80.7 | 144            | 19.3 | 6.634    | 0.036* |
| Sometimes                     | 3080              | 79.4 | 801            | 20.6 |          |        |
| Rarely/Never                  | 1599              | 76.9 | 479            | 23.1 |          |        |
| Consumption of eggs and beans |                   |      |                |      |          |        |
| Often/Always                  | 3068              | 80.0 | 769            | 20.0 | 8.208    | 0.017* |
| Sometimes                     | 1780              | 77.5 | 518            | 22.5 |          |        |
| Rarely/Never                  | 434               | 76.0 | 137            | 24.0 |          |        |
| Consumption of milk           |                   |      |                |      |          |        |
| Often/Always                  | 2353              | 79.1 | 621            | 20.9 | 0.412    | 0.814  |
| Sometimes                     | 1779              | 78.5 | 486            | 21.5 |          |        |
| Rarely/Never                  | 1150              | 78.4 | 317            | 21.6 |          |        |
| Consumption of rice           |                   |      |                |      |          |        |
| Often/Always                  | 4270              | 79.2 | 1124           | 20.8 | 5.758    | 0.056  |
| Sometimes                     | 828               | 78.1 | 232            | 21.9 |          |        |
| Rarely/Never                  | 184               | 73.0 | 68             | 27.0 |          |        |

\* $P < 0.05$ 

risks of multimorbidity were associated with independent factors (age, BMI, family history of hypertension, family history of diabetes, fatigue status, and fresh fruit consumption) (all  $P < 0.01$ ). Multimorbidity risks were related to aging (65–69 years old: OR = 3.53, 95%CI: 2.04–6.12; 70–74 years old: OR = 5.26, 95%CI: 3.02–9.17). Overweight participants had significantly high multimorbidity risks (OR = 2.76, 95%CI: 1.50–5.24). Family history of hypertension and family history of diabetes was significantly associated with high multimorbidity risks (family history of hypertension: OR = 2.34, 95%CI: 1.96–2.79; family history of diabetes: OR = 1.77, 95%CI: 1.38–2.26). Compared with the frequency of fatigue (< 1 time/week or 1–2 times/week), that ( $\geq 3$  times/week) was associated with high multimorbidity risks (OR = 1.39, 95%CI: 1.07–1.81). For fresh fruit consumption, compared with participants eating fruits regularly, those eating rarely had higher risks of multimorbidity (OR = 2.33, 95%CI: 1.90–2.85). The C-index of the nomogram was 0.650.

## Discussions

In this paper, we documented that the prevalence of multimorbidity is 21.2% among the adult residents. In addition, the risks of multimorbidity are associated with age, BMI, family history of hypertension, family history of diabetes, fatigue status, and fresh fruit consumption.

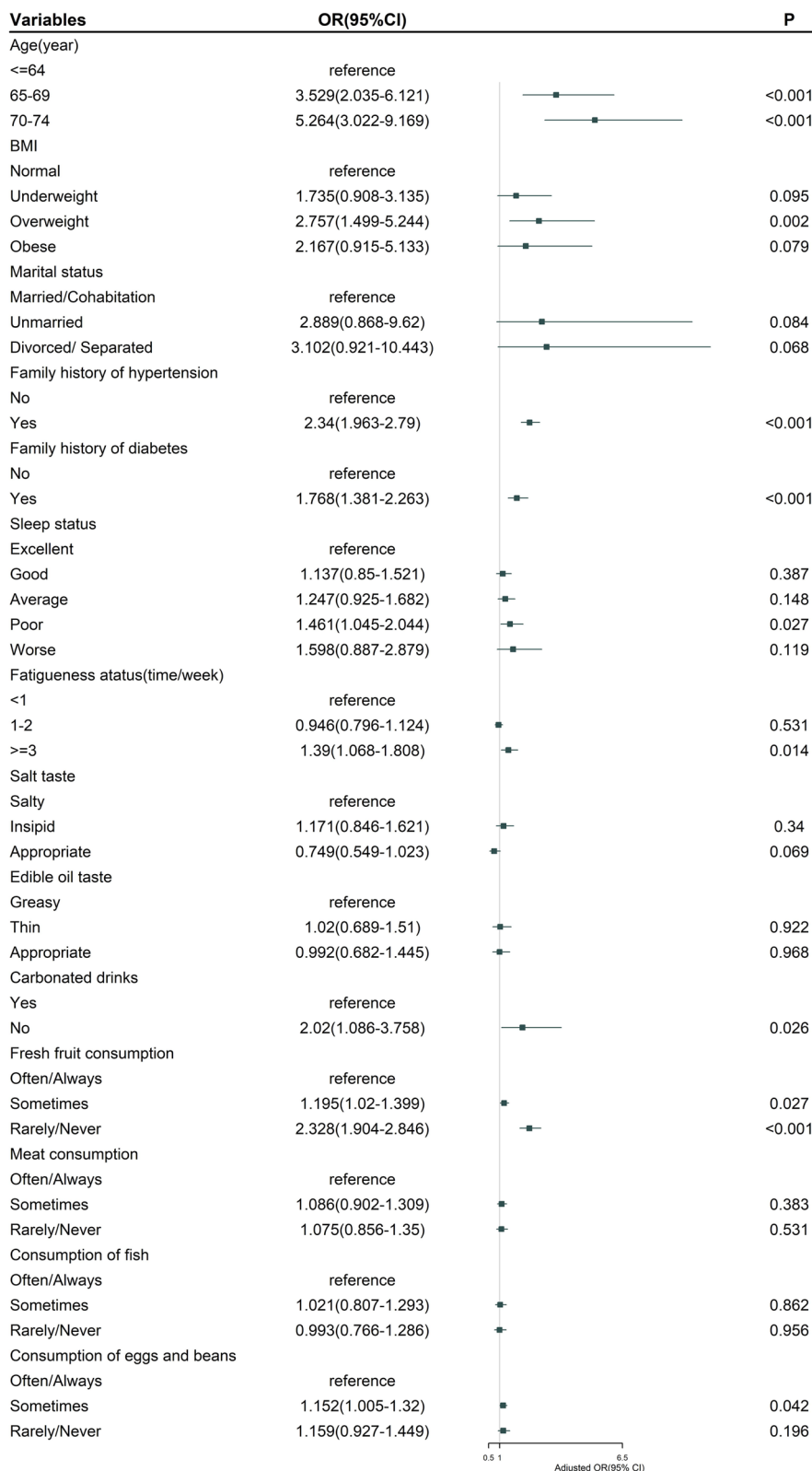
The prevalence of multimorbidity in our study in 2019 is substantially lower than that in the study of Wang et al. in 2012 [34]. The decrease in prevalence of multimorbidity in northeastern China may be due to

the implementation of chronic disease prevention and control strategies in decades. Actually, chronic disease prevention and control, supported by series projects focusing on chronic noncommunicable disease prevention and control, have been proceeding in northeastern China. With nationally spreading of 5G networks, healthcare systems conduct precise prevention and control for individuals with multimorbidity.

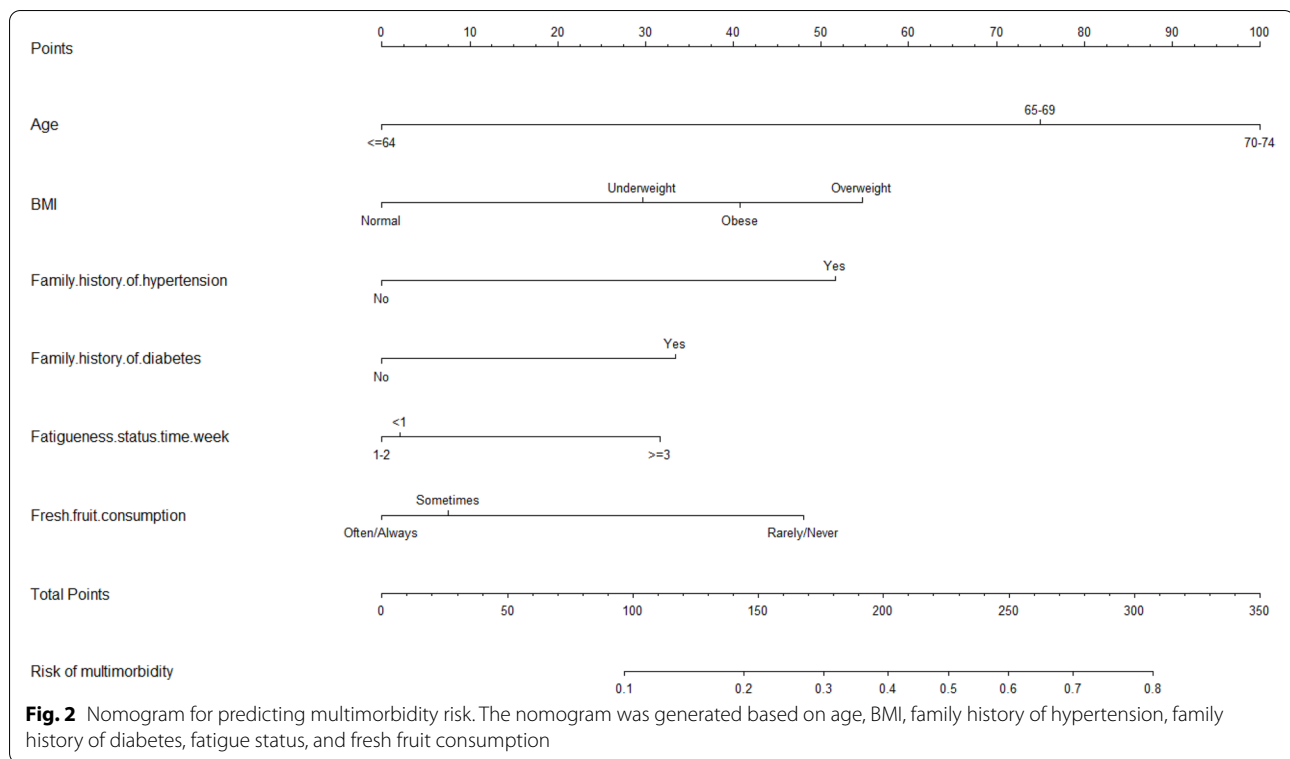
Aging has been widely considered to be associated with risks of multimorbidity [5, 35]. In agreement with other studies [36–38], our study also found that the prevalence of multimorbidity increased dramatically with aging. Moreover, consistent with other studies [25, 39, 40], our study found BMI influenced multimorbidity. Zhang et al. conducted a national investigation, finding that obesity is associated with the risk of multimorbidity in whole China [41]. Surprisingly, we corroborated that obesity was neither protect factor nor risk factor of multimorbidity in Northeastern China.

We identified the risk factors of multimorbidity (the family history of hypertension, family history of diabetes, and fatigue status [ $\geq 3$  times/week]) in northeast China. These factors confer perception to connections implicated in multimorbidity. Thus, people with these three characteristics should pay more attention to their health and strengthen their awareness of prevention and control. In addition, for fresh fruit consumption, similar to the results of Ruel et al. [42], our results also showed that greater consumption of fruits appears to lower risks of multimorbidity.





**Fig. 1** Multivariate logistic regression analysis of factors associated with multimorbidity



Multimorbidity increases the risk of disability and mortality [43–45], necessitating the identification of influencing factors of multimorbidity. Moreover, our nomogram also provides effective and reliable guides for the risk-prediction, prevention, and control of multimorbidity. Overall, the adult residents with three characteristics (family history of hypertension, family history of diabetes, and fatigue status) are the population with high risk of multimorbidity. The three characteristics provide theoretical and precisely practical guidelines to prevent and control multimorbidity, such as controlling weight and increasing consumption of fruits.

There are strengths in this study, including the large sample size, comprehensive sociodemographic and behavioral characteristics, and region representativeness of northeast China. However, some limitations also exist. First, the causality between multimorbidity and risk factors could not be reflected in our cross-sectional design. Second, the data in this study were based on self-reported questionnaires; therefore, the accuracy of the reported results cannot be determined.

## Conclusion

In conclusion, the prevalence of multimorbidity is 21.2% among the adult residents of northeastern China. Sociodemographic indices (age, BMI, family history of

hypertension, and family history of diabetes) and behavioral indices (fatigue status and fresh fruit consumption) increase the risks of multimorbidity. This study provides a necessary route to prevent and control multimorbidity in northeast China.

## Abbreviations

CI: Confidence Intervals; OR: Odds Ratios.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-022-12722-y>.

**Additional file 1: Supplemental Figure 1.** Inclusion and exclusion criteria and selection process of participants.

**Additional file 2: Supplemental Table 1.** Definition of variables.

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## Authors' contributions

Yawen Liu, Yi Cheng, and Siyu Liu designed the study. Jikang Shi, Yanbo Guo, Zhuoshuai Liang, Lingfeng Pan, and Yang Yu performed the study. Jikang Shi, Yanbo Guo, Weifei Zhu, Aiyu Shao, and Zhen Li analyzed the data, Jikang Shi drafted the manuscript. Wenjun Chen and Chao Gao participated in revising the manuscript. All authors approved the final manuscript.

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#### Availability of data and materials

All data generated or analysed during this study are included in this published article.

#### Declarations

##### Ethics approval and consent to participate

The study was approved by the Ethics Committee of China Medical University. The study protocol is performed in accordance with the principles outlined in the Declaration of Helsinki and informed consent was obtained from all the subjects.

##### Consent for publication

Not applicable.

##### Competing interests

The authors declare that there is no competing interests regarding the publication of this article.

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